Lecturer – Chemistry
Inverness College UHI
RATIONALE

Retention vs transfer
RATIONALE

Retention vs transfer

Retention: recall of learned facts
RATIONALE

Retention vs transfer
Retention: recall of learned facts
Transfer: applying learned material to a novel situation

RATIONALE

Retention vs transfer

Students perform well when recalling learned lists (elements in a Group of the Periodic Table, lists of historical dates) but less well when applying knowledge to solve problems.
RATIONALE

Retention vs transfer

Students perform well when recalling learned lists (elements in a Group of the Periodic Table, lists of historical dates) but less well when applying knowledge to solve problems.
RATIONALE

Applying learned knowledge to solve problems helps students to generalize.
RATIONALE

To allow them to do this, they must have a store of relevant knowledge
RATIONALE

To allow them to do this, they must have a store of relevant knowledge.
For example, “vocabulary of chemistry.”
RATIONALE

Chemistry vocabulary

Type 1 words: spelling and meaning unique to chemistry

Type 2 words: words which occur in both general AND chemistry English, but with different meanings
<table>
<thead>
<tr>
<th>Type 1 words</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkane</td>
<td>Hydrocarbon compound with no double or triple carbon to carbon bonding</td>
</tr>
<tr>
<td>Ester</td>
<td>Compound formed from reaction of an alcohol with an acid with loss of a water molecule</td>
</tr>
<tr>
<td>Exothermic</td>
<td>Reaction which gives out energy as heat</td>
</tr>
<tr>
<td>Polymer</td>
<td>Large molecule built up of large numbers of individual units (monomers)</td>
</tr>
<tr>
<td>Enthalpy</td>
<td>A thermodynamic function of state which may be considered as the “chemical potential energy” of a system</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type 2 words</th>
<th>Everyday meaning(s)</th>
<th>Chemistry meaning(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Headquarters, platform</td>
<td>Source of electrons, chemical species which will neutralise an acid</td>
</tr>
<tr>
<td>Period</td>
<td>Time interval, specific part of history</td>
<td>Row in the Periodic Table of the Elements corresponding to the filling of an electron shell</td>
</tr>
<tr>
<td>Reduce</td>
<td>Make smaller, make simpler</td>
<td>Donate electrons, change to a lower oxidation state, combine with hydrogen, remove oxygen</td>
</tr>
<tr>
<td>Saturated</td>
<td>Soaking wet, fully occupied</td>
<td>Unable to undergo addition reactions, only substitution reactions because of a lack of carbon to carbon double or triple bonds; (of a solution) – unable to dissolve any more material</td>
</tr>
<tr>
<td>Solution</td>
<td>The answer to a problem or question</td>
<td>A homogeneous mixture with a solute distributed in a solvent (a dissolving medium)</td>
</tr>
<tr>
<td>Highest Order</td>
<td>Research and Creativity Skills</td>
<td>Applied Chemistry</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td>Project Planning and Execution</td>
<td>Problem Solving</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practical Skills</td>
</tr>
<tr>
<td>Lowest Order</td>
<td>Team Working and Inclusivity</td>
<td>Chemistry fundamentals (core knowledge)</td>
</tr>
<tr>
<td></td>
<td>Oral Communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scientific Literacy and Criticism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Independent Thinking</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Smith, D., 2016, “Designing Skilful Chemists”, *Education in Chemistry*, 53(4), 18-21
### RATIONALE

<table>
<thead>
<tr>
<th>Highest Order</th>
<th>Research and Creativity Skills</th>
<th>Project Planning and Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Team Working and Inclusivity</td>
<td>Oral Communication</td>
</tr>
<tr>
<td></td>
<td>Scientific Literacy and Criticism</td>
<td>Independent Thinking</td>
</tr>
<tr>
<td></td>
<td>Applied Chemistry</td>
<td><strong>Problem Solving</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Practical Skills</td>
</tr>
<tr>
<td>Lowest Order</td>
<td><strong>Chemistry fundamentals (core knowledge)</strong></td>
<td></td>
</tr>
<tr>
<td>Highest Order</td>
<td>Lowest Order</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Research and Creativity Skills</td>
<td>Chemistry fundamentals (core knowledge)</td>
<td></td>
</tr>
<tr>
<td>Project Planning and Execution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Working and Inclusivity</td>
<td>Problem Solving</td>
<td></td>
</tr>
<tr>
<td>Oral Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific Literacy and Criticism</td>
<td>Practical Skills</td>
<td></td>
</tr>
<tr>
<td>Independent Thinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applied Chemistry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Smith, D., 2016, “Designing Skilful Chemists”, *Education in Chemistry*, 53(4), 18-21
RATIONALE

Higher order cognitive skills

CONSTRUCTIVIST MODEL
RATIONALE

Higher order cognitive skills

CONSTRUCTIVIST MODEL

Students combine new information with existing subject knowledge (vocabulary and skills) to construct new knowledge.
RATIONALE

Higher order cognitive skills

CONSTRUCTIVIST MODEL

Students combine new information with existing subject knowledge (vocabulary and skills) to construct new knowledge.
RATIONALE

Higher order cognitive skills

CONSTRUCTIVIST MODEL

Students combine new information with existing subject knowledge (vocabulary and skills) to construct new knowledge.
Sensory memory

Receives new information
Sensory memory

Receives new information

Long term memory

Pool of existing knowledge
Sensory memory

- Receives new information

Working memory

- Processing of information

Long term memory

- Pool of existing knowledge
Input – new information

Sensory memory

New information and existing knowledge are combined

Working memory

Long term memory

Existing knowledge called on to help make sense of new information
New information and existing knowledge are combined in the working memory. Existing knowledge is called on to help make sense of new information. New knowledge is constructed.
New information and existing knowledge are combined to form new knowledge. This new knowledge is then stored in the long-term memory. If the new knowledge is relevant, it joins the pool of existing knowledge in the long-term memory.
New information and existing knowledge are combined in the working memory. New knowledge is constructed and then joins the pool of existing knowledge in the long-term memory, contributing to learning.
Sensory memory

Input – new information

New information and existing knowledge are combined

Working memory

New knowledge is constructed

New knowledge joins pool of existing knowledge in long-term memory

Long term memory

LEARNING

Adapted from Roberts and Rosnov, 2006
RATIONALE

Higher order cognitive skills

COMMUNITIES OF PRACTICE
RATIONALE

Higher order cognitive skills COMMUNITIES OF PRACTICE

Fluency in the vocabulary of a discipline, and ability to solve problems, will help students to join, and be accepted by, the “learning community”
RATIONALE

Puzzles and games have been used throughout human history as tools to aid learning in such a way as to make learning fun.
RATIONALE

Puzzles and games have been used throughout human history as tools to aid learning in such a way as to make learning fun.

Crosswords are an example.
Students using crossword puzzles as a learning tool have reported:
Students using crossword puzzles as a learning tool have reported:

- Having fun doing the puzzles as part of a lesson
RATIONALE

Students using crossword puzzles as a learning tool have reported:
• Having fun doing the puzzles as part of a lesson
• Enhanced learning of vocabulary associated with the discipline
RATIONALE

Students using crossword puzzles as a learning tool have reported:

• Having fun doing the puzzles as part of a lesson
• Enhanced learning of vocabulary associated with the discipline
• Ability to revise course material better
RATIONALE

Students using crossword puzzles as a learning tool have reported:
• Having fun doing the puzzles as part of a lesson
• Enhanced learning of vocabulary associated with the discipline
• Ability to revise course material better
• Enhanced learning of course material
RATIONALE

Students using crossword puzzles as a learning tool have reported:

• Having fun doing the puzzles as part of a lesson
• Enhanced learning of vocabulary associated with the discipline
• Ability to revise course material better
• Enhanced learning of course material
• Enhanced ability to solve problems
LITERATURE
Theory of crossword puzzles


Information Processing Model

Developing Higher Order Skills in Chemistry


Crossword Puzzles in Chemistry


Crossword puzzles in other disciplines


Crossword puzzles in other disciplines


Communities of Practice


Communities of Practice / “Academic Tribes”


PLANNING

Prepare puzzles for use as part of revision for Unit assessments in the Higher Chemistry course
PLANNING

Prepare puzzles for use as part of revision for Unit assessments in the Higher Chemistry course

Unit 1 – Chemical Changes and Structure
PLANNING

Prepare puzzles for use as part of revision for Unit assessments in the Higher Chemistry course

Unit 1 – Chemical Changes and Structure
• Controlling the rate of reaction
• The Periodic Table – bonding and structure
• Trends in The Periodic Table
• Bonding in compounds
PLANNING

Prepare puzzles for use as part of revision for Unit assessments in the Higher Chemistry course

Unit 2 – Nature’s Chemistry
PLANNING

Prepare puzzles for use as part of revision for Unit assessments in the Higher Chemistry course

Unit 2 – Nature’s Chemistry
• Alcohols, carboxylic acids and esters
• Fats, oils and soaps
• Proteins
• The chemistry of cooking and oxidation of food
• Fragrances
• Skin care
PLANNING

• All clues were composed by me
• Clues were composed in the cryptic style, with varying degrees of difficulty
• All solutions were to be relevant to the Course material
• Puzzle grids were generated using free online crossword puzzle compiler Armored Penguin

Armoredpenguin (2016), crossword puzzle generator
http://www.armoredpenguin.com/crossword/
[Accessed : 28th November 2016]

The grids look quite professional! Here are a couple of examples of my puzzles.
HIGHER CHEMISTRY UNIT 1
Dr. Anthony Luke

A crossword puzzle to help you revise Unit 1 - Chemical Changes and Structure. Some clues are easy, some are harder, and some are fiendish! Work together and solve the clues!

HIGHER CHEMISTRY UNIT 2
Dr. Anthony Luke

A crossword puzzle to help you revise Unit 2 - Nature’s Chemistry. Some clues are simp's, others more tricky, and some of them are stinkers! Work together to solve the clues - and have fun!
COMPOSING CLUES
COMPOSING CLUES

• Must be RELEVANT to the subject matter
• Different styles of clues make puzzles more interesting.
• Range of complexity – encourages students to work together. Some clues easy, others harder
• Include the number of letters in the solution.

From ‘missing word’ to ‘cryptic’ clues
COMPOSING CLUES

- Must be RELEVANT to the subject matter
- Different styles of clues make puzzles more interesting.
- Range of complexity – encourages students to work together. Some clues easy, others harder
- Include the number of letters in the solution.

From ‘missing word’ to ‘cryptic’ clues

missing word - the simplest clues: “The unit of thermodynamic temperature is the ______ (6)” – KELVIN
COMPOSING CLUES

• Must be RELEVANT to the subject matter
• Different styles of clues make puzzles more interesting.
• Range of complexity – encourages students to work together. Some clues easy, others harder
• Include the number of letters in the solution.

From ‘missing word’ to ‘cryptic’ clues

*missing word* - the simplest clues : “The unit of thermodynamic temperature is the _______ (6)” – KELVIN

*Cryptic, no anagram* – hint at the solution in an indirect way. For example – “royal elements too posh to mix with the riff-raff (5, 5)” – NOBLE GASES
COMPOSING CLUES

- Must be RELEVANT to the subject matter
- Different styles of clues make puzzles more interesting.
- Range of complexity – encourages students to work together. Some clues easy, others harder
- Include the number of letters in the solution.

From ‘missing word’ to ‘cryptic’ clues

**missing word** - the simplest clues: “The unit of thermodynamic temperature is the _______ (6)” – **KELVIN**

**Cryptic, no anagram** – hint at the solution in an indirect way. For example – “royal elements too posh to mix with the riff-raff (5, 5)” – **NOBLE GASES**

**Cryptic with anagram** – Rearrange the letters of the solution to make anagrams: great fun! – make sure that the clue includes a hint at the solution as well as an ‘anagram signifier’ like “break up”, “break down”, “change”, “transform” etc. for example:
COMPOSING CLUES

• Must be RELEVANT to the subject matter
• Different styles of clues make puzzles more interesting.
• Range of complexity – encourages students to work together. Some clues easy, others harder
• Include the number of letters in the solution.

From ‘missing word’ to ‘cryptic’ clues

missing word - the simplest clues: “The unit of thermodynamic temperature is the _______ (6)” – KELVIN

Cryptic, no anagram – hint at the solution in an indirect way. For example – “royal elements too posh to mix with the riff-raff (5, 5)” – NOBLE GASES

Cryptic with anagram – Rearrange the letters of the solution to make anagrams: great fun! – make sure that the clue includes a hint at the solution as well as an ‘anagram signifier’ like “break up”, “break down”, “change”, “transform” etc. for example:

“Type of process involving protein catalyst to break down meaty zinc” (9, anagram) - ENZYMATIC
IMPLEMENTATION

• Puzzles were given out to the Higher Chemistry class, and completion instructions were given
• Students were allowed full access to revision materials and were encouraged to work together to do the puzzles – not compulsory
• Students were given anonymous written feedback forms to comment on the crossword puzzles
FEEDBACK

Anonymous written feedback form
<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree (+2)</th>
<th>Agree (+1)</th>
<th>Neither agree nor disagree (0)</th>
<th>Disagree (-1)</th>
<th>Strongly disagree (-2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The crossword puzzles were fun to do</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The crossword puzzles made me look at my notes and textbook more thoroughly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The crossword puzzles helped me to understand the course material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The crossword puzzles were relevant to the course</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The crossword puzzles helped me to understand chemical terms better</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing the crossword puzzles has helped me to solve chemistry problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing the crossword puzzles has helped me to revise for assessment better</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The crossword puzzles made it easier for me to learn the course materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## FEEDBACK

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree (+2)</th>
<th>Agree (+1)</th>
<th>Neither agree nor disagree (0)</th>
<th>Disagree (-1)</th>
<th>Strongly disagree (-2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The crossword puzzles were fun to do</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles made me look at my notes and textbook more thoroughly</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles helped me to understand the course material</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles were relevant to the course</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles helped me to understand chemical terms better</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Doing the crossword puzzles has helped me to solve chemistry problems</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Doing the crossword puzzles has helped me to revise for assessment better</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles made it easier for me to learn the course materials</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Statement</td>
<td>Strongly agree (+2)</td>
<td>Agree (+1)</td>
<td>Neither agree nor disagree (0)</td>
<td>Disagree (-1)</td>
<td>Strongly disagree (-2)</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>------------</td>
<td>--------------------------------</td>
<td>---------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>The crossword puzzles were fun to do</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles made me look at my notes and textbook more thoroughly</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles helped me to understand the course material</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles were relevant to the course</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles helped me to understand chemical terms better</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Doing the crossword puzzles has helped me to solve chemistry problems</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Doing the crossword puzzles has helped me to revise for assessment better</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The crossword puzzles made it easier for me to learn the course materials</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
FEEDBACK

No negative feedback (‘disagree’ or ‘strongly disagree’)
FEEDBACK

No negative feedback (‘disagree’ or ‘strongly disagree’)

Highest agreement was with the statement that the puzzles were relevant to the course
FEEDBACK

No negative feedback (‘disagree’ or ‘strongly disagree’)

Highest agreement was with the statement that the puzzles were relevant to the course

High agreement that puzzles were fun to do, that they helped students understand the subject material, and that they helped students revise
FEEDBACK

No negative feedback (‘disagree’ or ‘strongly disagree’)

Highest agreement was with the statement that the puzzles were relevant to the course

High agreement that puzzles were fun to do, that they helped students understand the subject material, and that they helped students revise
FEEDBACK

No negative feedback (‘disagree’ or ‘strongly disagree’)

Highest agreement was with the statement that the puzzles were relevant to the course

High agreement that puzzles were fun to do, that they helped students understand the subject material, and that they helped students revise
CAUTION

• Don’t overuse puzzles and games
• Use them sparingly, at the right time
• Don’t compel students to use them
• Offer them as an additional, fun learning tool
• Students must be more than good crossword solvers!
Thank you for listening!

Anthony.Luke.ic@uhi.ac.uk

Please get in touch for copies of crossword puzzles, libraries of clues and other useful stuff