Neural-Pathway Enhanced Learning Framework (NPL)

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Outline

- What is Neural Pathway Based Learning?
- Existing Research Projects
  - Active Learning in Software Engineering
  - MCQ Based Learning
  - Drop & Drag & Puzzle Based Learning
  - Problem Based Learning
- Leeds Beckett NPL Framework
- CASE STUDY: STEM Course
- Lessons Learned
- Conclusion & Further Work
What is Neural pathway based Learning & Why We need to consider in STEP subjects?
The Power of Human Brain & Learning Theories: Why do we forget?

Our brain has a virtually limitless potential to learn new things - so why do we seem to forget so much of what we’ve read just hours or days ago, and why is studying so stressful?
### The power of the Human Brain vs. The Computer Machine

<table>
<thead>
<tr>
<th>Specification</th>
<th>K Computer (Japan)</th>
<th>TH-2 (China)</th>
<th>The Human Brain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>10 petaFLOPS</td>
<td>33.86 PFLOPS</td>
<td>100 petaFLOPS</td>
</tr>
<tr>
<td><strong>Power Consumption</strong></td>
<td>12.6 MW (9.89x10⁶) watts</td>
<td>17.6 MW (24 MW with cooling)</td>
<td>20-25 watts</td>
</tr>
<tr>
<td><strong>Equals to</strong></td>
<td>10⁶ linked desktop computers</td>
<td>10⁶ linked desktop computers (unfortunately located in southern China where it hot, therefore increase in energy consumption by 10% more early). Apparently very hard to learn to code</td>
<td>1.22x10⁶ linked desktop computers</td>
</tr>
<tr>
<td><strong>Uses Processors (Architecture)</strong></td>
<td>88,128 SPARC64 VIIIfx processors, Tofu interconnect (each processor which is core i8, i.e 5.5x10⁵ cores)</td>
<td>32,000 Intel Xeon E5-2692 12C with 2.200 GHz 48,000 Xeon Phi 31S1P</td>
<td>15 to 100 billion neurons (15 to 100)x10⁹. Each neuron having nearly 1K to 10K synaptic connections. This is similar to 1K-10K parallel processor for each neuron. Therefore, number of operational components (the speed) is between</td>
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Research shows that we forget a staggering 40% of what we’ve learnt after just 20 minutes, and this increases to 80% after just one week (Thalheimer, 2010).

Researchers found that we can only hold 7 things in our short term memory at one time (9 at best). This is an experiment you can easily try yourself; write a bunch of words down on a piece of paper, turn it around and then see how many you can remember after just 30 seconds – it’ll be 7, give or take 2 depending on what you were up to at the weekend (Synap 2017).

Most people study by reading textbooks (and last minute cramming! Exams!)

The Surprising Neuroscience Behind How We Learn
What are Neural Pathways?

* Neurone = nerve cell (our brain is made up of 100 billion)
* Neural pathway – pathway along which information travels
* Retaining information in our long term memory depends on the strength of connections between neurones (nerve cells)
* Strength of the connection increases by repetition (and revisiting the information in different ways)
* This is difficult to achieve simply be reading a textbook because learning is an effortful and active process
* Research in the fields of cognitive neuroscience and educational psychology have shown that various different methods (which I will talk about) can be used to enhance learning
* [How we learn Synapses and Neural Pathways? Video Link](#)
Neurones are nerve cells. They carry information as tiny electrical signals. There are three different types of neurones, each with a slightly different function. A neural pathway is responsible for connecting a specific part of the nervous system to another by a bundle of axons, which are also the long fibres of neurons. The pathway helps to connect parts of the brain or nervous system that are distant, and are typically known and seen as white matter.

Examples of Techniques

* **Active Elaboration** – Active Learning can take many forms from role playing to problem solving where learners are actively engaged in the learning process. Using the knowledge gained from previous experience, Making things, Developing Creative Thinking, Group Work, Reflective Learning, Giving and Receiving Feedback, etc.

* **Spaced Repetition** is a learning technique that incorporates increasing intervals of time between subsequent review of previously learned material in order to exploit the psychological spacing effect.

* **Interleaved Practice** Block practicing is when you focus on learning one skill at a time. You practice a skill repetitively for a period of time and then you move onto another skill and repeat the process. Interleaving practice on the other hand involves working on multiple skills in parallel. [http://j2jenkins.com/2013/04/29/interleaved-practice-a-secret-enhanced-learning-technique/](http://j2jenkins.com/2013/04/29/interleaved-practice-a-secret-enhanced-learning-technique/).

* **Rehearsals** is useful to improve the processing power rather than focusing on short-term and long-term memories.
Levels of processing: The idea that the way information is encoded affects how well it is remembered. The deeper the level of processing, the easier the information is to recall. STM → Short Term memory, LTM - Long Term memory

http://www.simplypsychology.org/levelsofprocessing.html
What we have Practiced?
Waterfall model puzzle Link

Tried in many different classes over 10 year period

100% attempt, everyone did play which is positive and how motivated us for NPL Project

However, unfortunately, only 10-20% did get this right in their first attempt!

We also don’t have the luxury of having an introductory module to Software Engineering and I use this in the first week to introduce software development activities as we get learners from different background

A Good example of memory recall/recollecting which emphasis basic scientific theories played over and over to retain their learning for years to come.

This was also useful to test their pre-requisite knowledge required for this module

This type of learning is linked to early learning process (lego’s), zigzaw puzzle

Observations on Computing and Engineering UG & PG students

This underpins Vygotsky, Piaget and Minsky’s Learning theory of Cognitive and practicing.

The more the students at UG and PG practiced the better the results of the puzzle.
Research Challenges in STEM Subjects such as Computing/Software Engineering

- What makes us to learn?
- How are effective learning and teaching strategies in advanced IT/Software Development Subjects that encourages ‘All’ to Learn?
- How can we create interest and motivate learning advanced topics in IT/SD Subjects with some fun?
- How can we engage students in class room?
- How can we use technology enhanced learning techniques in STEM subjects?
- How can we adopt Technological aspects supporting *Technological Pedagogical Content Knowledge Framework (TPACK)*?
NPL Based Practices Adopted

Interleaved Practice
- Research as well as Practical/Hands-ON (to reinforce understanding of the concept as well as practical applications)

Active Elaboration
- Active Learning in Software Engineering: L6 students role playing as Group Project managers for L5 Group Projects
- MCQ Based Learning provides instant feedback
- Puzzle based Learning provides reflective thinking, Develops creativity thinking

Spaced repetition
- Drop & Drag Puzzles
- Problem Based Learning
- Separating Lectures, Tutorials & Lab Sessions
- Increasing Contact Hours Working with Learners on a Small Projects

Active Elaboration
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Previous & Current Projects on Teaching & Learning

* Existing Research Projects
  * Problem & Practice Based Learning in Computing
    * Pedagogy and Research
    * Teaching Practices
  * Puzzle & Games Based Learning
  * Multiple Choice Quiz (MCQ) Based Learning
  * Interactive Multimedia Based Learning (HEA ICS Funded Project)
  * Technology Enhanced Learning
  * Active Learning in Software Engineering (Managing L5 Group Projects by L6 SE Learners)
Towards Developing a NPL Framework
Leeds Beckett NPL Framework

Active Learning Cycle
- Active Elaboration
- Active Learning
- Interleaved Practice
- Problem/Practice Based Learning (PBL)
- Virtual Reality Based Learning
- Machine Learning to Learn About the Learner (LLAL)

Thinking Cycle
- Analogy
- Experience & Real Life Stories
- Mental Activities and Ways of Thinking by AI Expert Minsky (2006)
  The Human Machine Learning by creating Mistakes and deliberately
  Using Learning Techniques to Learn About the Learners Activities

Testing/Solution Cycle
- Test
- Discussion
- Presentation
- Exam
- Interviews
- Apply VR & LLAL framework

Digest Cycle
- Spaced Repetition
- Rehearsal
- Puzzle
- Multiple Choice Questions (MCQ)
- Apply LLAL framework

Neural Pathway Enhanced Learning (NPL)
PG & UG Course Selected
Case Study on MSc/MEng CS/SE/I&T Courses Delivery

- MSc Courses: Software Engineering, Software Components and Architecture, Service-Oriented Architecture, Cloud Computing, etc.
- Five weeks of concept elaboration: Weekly Lecture followed by tutorial consists of problem-based learning activities, design creativity exercises, MCQ, Puzzle, Social Media Contents (YouTube, other relevant online content that reinforces the basic concepts, software design principles, building the foundation).
- The concept topics are clearly divided into knowledge crunches: concept, rationale, principle behind, building the strong foundation on the topic.
- Five weeks of hand-on lab sessions with smaller examples, hand-on exercises.
- Formative Assessment: weekly NPL MCQ, Puzzle (Drag & Drop) VLE immediate feedback (formative).
- Summative Assessment: Component 1 Research Report, choosing a topic & closely work with students to develop a good & publishable research (a list of research topic briefing is provided as part of their assessment spec.).
- Component 2: Developing a prototype product innovation based on component 1 research topic.
Technology Enhanced Neural Pathway Based Learning Environment
This Learning Environment is part of a Separate Learning Environment for Developing Content for Problem Based Active Elaboration for Component Based Programming and Service-Oriented Programming/Development (on progress)
Active Elaboration with MCQ, Drop & Drag Puzzle, Game Based Learning Activities, and Active Learning
Multiple-Choice (MC) items have many advantages that make them widely used and highly regarded. They also have disadvantages, some of which can be reduced by careful attention to good item-writing and item analysis practice.

Advantages of Multiple-Choice Items

- **Versatility** -- MC items are adaptable to the measurement of a wide variety of learning outcomes including reasoning, making inferences, solving problems, exercising judgment and demonstrating knowledge of facts through interpretation and analysis of information.
- **Efficiency** -- Because of the large number of items that can be posed in a given length of time, MC items permit wide sampling and broad coverage of the content domain.
- **Scoring accuracy and economy** -- Expert agreement on the correct answer to MC items is easy to obtain, and machine or clerical assistants can economically apply scoring keys.
- **Reliability** -- Consistency in scoring and wide sampling of content provide test results that can be generalized to the domain of interest.

Synap (2016) MCQ Based Learning, [www.synap.ac](http://www.synap.ac) – Applied MCQ in the Medical School, Leeds University, Crowdsourced funded product
Development Environment with Articulate Drag & Drop Puzzle and MCQ True-false sample

Two basic types of service oriented solution logic are service and services and service compositions.

- True
- False
The concept of SOA is based on service paradigm and most of the existing and emerging technologies are based on the SOA paradigm. Once this is injected deeply into their Neural Pathway, they can learn any emerging technologies. This is our main motivation. The exercise is to drag and drop the items at the bottom into the right place and to remembering what technologies used to describe them, services are described in WDSL and are requested using SOAP/RESTful.
Spaced Repetition with Problem-Based Learning
Problem Based Learning

Well established technique which needs to adopted with closely monitored learning activities to be more efficient.

1. Given the problem → find the design solution → code
2. Code → Design → Problem
Active Elaboration with Active Learning Practice in SE Course Adopted
The aims of this approach are to make students learn themselves by doing it rather than only by reading and instructing them in a classroom or in a lab.

We have adopted an active based learning approach to teach final year BSc students in Software Engineering. We let the final year students manage group projects carried out by level 5 students.

This work on active learning has changed our way of teaching software engineering and it has made a significant impact on the way the students learning and have been taught traditionally.

More than 90% of students felt they had gained deeper understanding of the content & practical application knowledge more deeply with active learning than otherwise.

This has also developed their divergent thinking, collaborative learning, and learning through differentiated assessments.
Active Learning Process

- Participants/Active Learners - 2nd Year BSc (Hons)

- Learning objectives on Group based/Team based Software Development Project

- Active Learning

- Software Management with specific Learning objectives & teaching principles of key skill sets: divergent thinking, collaborative learning, and differentiated assessment

- Expected learning outcome

- Cloud Based Technology Enhanced Learning Environment

- Subject-Specific Learning Environment (Reusable Learning Objects and Learning services)

- Student Manager – Final Year BSc (Hons) Software Development

- Learning Environment for Neural Pathway Based Learning

Expected learning outcome

Participants/Active Learners - 2nd Year BSc (Hons)
Project Evaluation/Student Feedback
Student Feedback/Evaluation of Active Learning Strategy: Skills They Feel They Have Learned Well

SPM: Effective Application of Software Project Management Practices (over 90%)
U: Deeper Understanding of SPM Techniques (>85%)
TC: Team Communications & Dealing with Team Issues
CE: Application of SPM Cost Estimation Techniques (FP, COCOMO)
RE&D: Application of Requirements Engineering and Design Methods
Ref: Reflective Report Writing Skills
QM: Application of software quality assurance techniques & software metrics techniques
PM: Improved Presentation & Communication Skills
Types of NPL Based Learning Developed

- True/False: 87
- Choose more than one option: 27
- Ranking: 23
- Drag and Drop: 42
- Design based problem: 10
- Component Description Language: 9
- Problem Based Learning: 19
We have involved 13 participants to evaluate the project using structured interviews and questionnaires. There were 17 questions have been asked based on 7 different aspects. The participants have been asked to test full system. The overall results show that every aspect of NPL learning have achieved the score between 3.5 to 4.9 out of 5.
**Lessons Learned**

- Effective Learning & Teaching can be achieved in advanced topics in IT/CS/Software Engineering
- Combination of learning techniques that are repetitive but still fun/engages them to play with will enhance students learning
- Technology Enhanced Neural Pathway Techniques is one of the way forward in STEM subject areas along with Active learning Techniques such as field visit, industrial talks, etc.
- Working closely with students work has shown excellent outcome (mini project, incrementally improving their initial ideas, etc.)
Acknowledgement

* This project was funded by Centre for Learning & Teaching at Leeds Beckett University
Conclusion & Thank You

* NPL, Active Learning, Problem & Practice Based Teaching & Learning created good success for students
  * Increased employability
  * Motivated to do research studies
* Research lead to good teaching & preparing materials
* Pastoral support & Emotional Intelligence helps students motivation

Thank you…
* Synap (2016) MCQ Based Learning, [www.synap.ac](http://www.synap.ac)
* How we learn – Synapses and neural Pathways, [https://www.youtube.com/watch?v=BEwg8TepfQ](https://www.youtube.com/watch?v=BEwg8TepfQ)