Final Year Project Proposal Defense on Development of Measuring Technique to Study Synchronization in Learning Using fNIRS

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Chapter 1

INTRODUCTION

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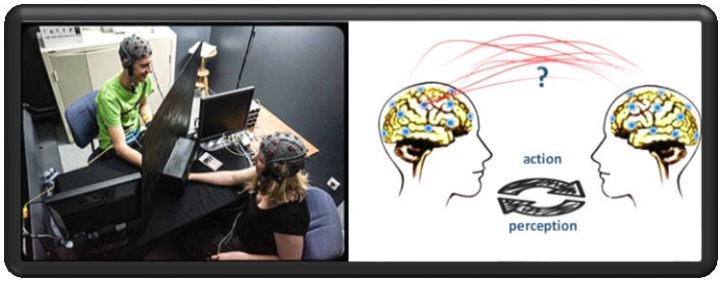
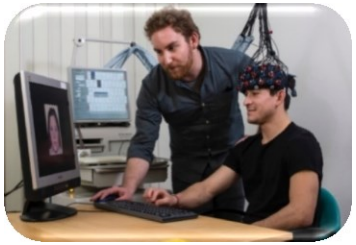
Background of Study

- Social interaction can be analyzed based on Interpersonal Neural Synchronization (INS) level by using functional neuroimaging and hyperscanning.



EEG

fMRI



fNIRS

Problem Statements

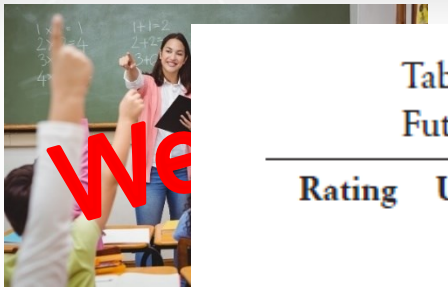


Table 1: Student Responses to Utilizing Social Interaction in Future Classrooms

Rating	Undergraduate content reading class (n=15) % of responses	Graduate content reading class (n=17) % of responses	Graduate practicum-based class (n=13) % of responses
10	33	47	76
9.5	-	41	8
9	26	-	8
8	20	12	8
7.5	7	-	-
7	7	-	-
6	-	-	-
5	7	-	-

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Hurst, B., Wallace, R. & Nixon, S. B. (2013). The Impact of Social Interaction on Student Learning. *Reading Horizons*. 52 (4).

Objectives

1. To design a protocol to measure oxygenation level of multiple brains in classroom learning.

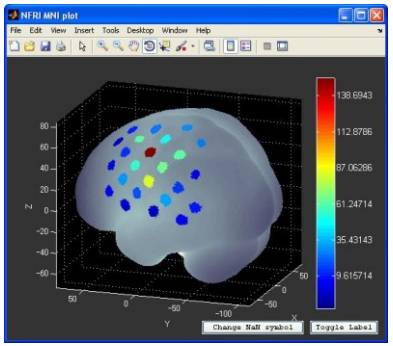
2. To measure Interpersonal Neural Synchronization (INS) level of multiple brains among teachers and/or students.

3. To perform statistical analysis on Functional Near-Infrared Spectroscopy (fNIRS) data with a comparison with behavioral assessment to identify the most effective approach in classroom learning.

Scope of Study

Functional Near-Infrared Spectroscopy

- The feasibility of hyperscanning?
- Experiment Tasks of Hyperscanning



MATLAB Data Processing

Chapter 2

LITERATURE REVIEW

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Hyperscanning

Studies	Findings
Comparison on Hyperscanning Neuroimaging Technique using EEG, fMRI and fNIRS ***Koike, T., Tanabe, H. C. & Sadato, N. (2014).***	1. EEG is good at inter-brains interaction effect recording but difficult to localize the epicenter of inter-brain effect. 2. fNIRS is better in temporal resolution and portability than fMRI. It also creates natural environment for hemodynamic level measuring.
Study on NIRS-Based Hyperscanning to measure INS level during cooperation in Jenga Game ***Liu, N. et al. (2016).***	The highest INS level was measured in right middle, superior frontal gyrus and prefrontal cortex cooperation stage in Jenga Game.
Study on fNIRS-based Hyperscanning to Measure Interpersonal Coherence Level in Superior Frontal Cortex Based on Competition, Cooperation and Single Tasks ***Cui, X. et al. (2011).***	The Wavelet Transform Coherence (WTC) level of individual is highly dependent on cooperation level but competition and individual tasks did not show significant increase in coherence level.
Study of fNIRS in prefrontal cortex activation during memory learning tasks ***Matsui, M., Tanaka, K., Yonezawa, M. & Kurachi, M. (2007).***	1. There was large change of hemoglobin level during memory task (encoding stage). 2. There was no significant change of hemoglobin level during task repetition (retrieval stage).
Study of fNIRS on Brain Connectivity During Imitation by Performing Paced Finger-Tapping Task (PFT) Between Instructor and Imitators ***Holper, L., Scholkmann, F. & Wolf, M. (2012).***	1. Larger Wavelet Transform Coherence (WTC) level was found during imitation (IM) condition as compared to control (CO) condition. 2. Greater extent of G-Causality existed in imitation of stimulus paced finger tapping compared to self-paced finger tapping.
Experiments on fNIRS to Enable Routine Functional Brain Imaging: Implementation of High Density and wearable fNIRS and advanced signal processing techniques to enhance fNIRS performance. ***Yücel, M. A. et al. (2017).***	1. High Density fNIRS provides more accurate brain activity and resting state mapping over different cortical regions. 2. Wearable fNIRS provides natural environment and more efficient brain monitoring system.

Why fNIRS?

Devices	fNIRS	EEG	fMRI
Technique	Hemodynamic	Electro-Magnetic	Hemodynamic
Portability	High	High	Low
Spatial Resolution	Medium (< 1 cm)	Low (1–2 cm)	High (2–3 mm)
Temporal Resolution	Medium (10 sample/s)	High (500 sample/s)	Low (1 sample in 2s)
Deep Brain Structure	Not Measurable	Not Measurable	Measureable
Social Interaction Environment	Measureable	Measureable	Not Measurable
Price	Lower	Lower	Higher

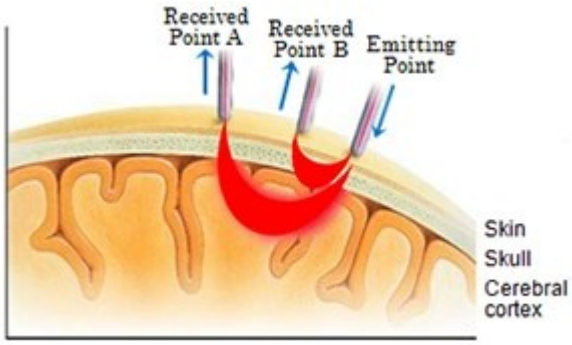
Koike, T., Tanabe, H. C. & Sadato, N. (2014). Hyperscanning neuroimaging technique to reveal the “two-in-one” system in social interactions. *Neuroscience Research*. 90, 25–32.

Wearable Optical Topography (WOT)

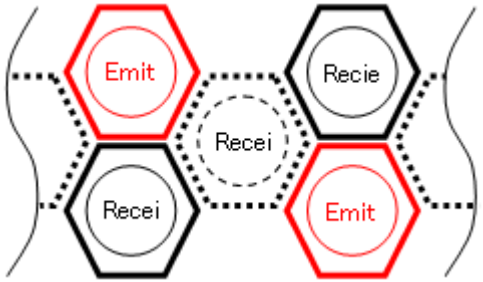
- Model used: Hitachi HOT-1000
- Wearable design fNIRS with high sensitivity of APDs (avalanche photodiodes).
- Functional imaging technique with the WOT system is applicable to OT and brain activation measurement while walking in a natural environment.
- The features of HOT-1000 enable simultaneous brain data capturing in natural environment.

Wearable Optical Topography (WOT)

- Measures the changes in concentration of hemoglobin (Hb) by radiating near-infrared light into the scalp and detecting the transmitted light from another position.
- Two kinds of Hb change, oxygenated (oxy-) and deoxygenated (deoxy-), are obtained by using two different absorption data according to the modified Beer–Lambert law (MBLL).



Biological noise is reduced using the received signals from points A and B

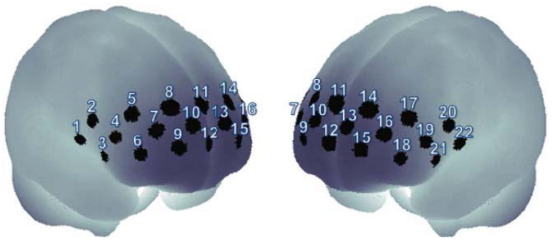


A multi-distance measurement mode is offered by positioning additional receivers.

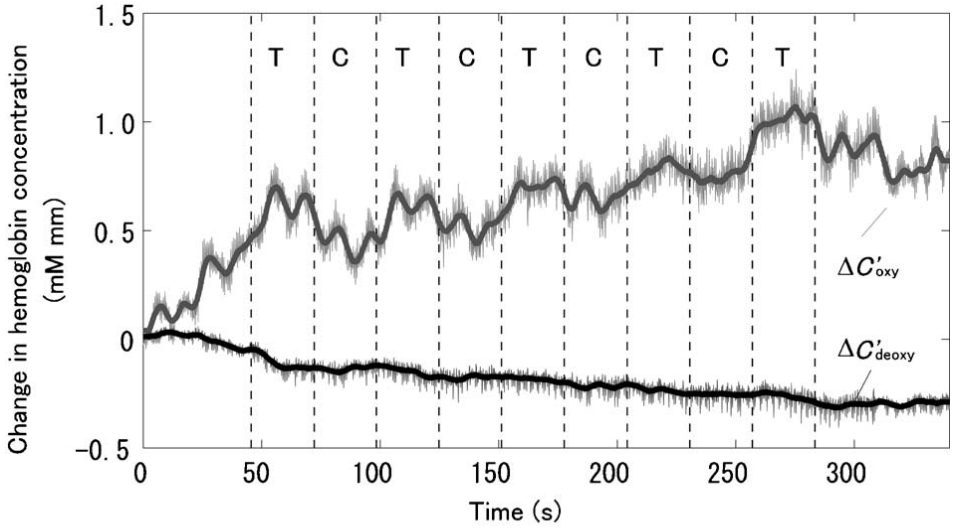
Science of Learning

Studies	Findings
Study on Impact of Social Interaction on Student Learning: **This study investigate students' perspective based on three courses on how important social interaction in classroom learning is.** ***Hurst, B., Wallace, R. & Nixon, S. B. (2013).***	Students from all three courses agree that social interaction is important to enhance not only their learning but also problem solving skills.
Study on how the relationship between students and teachers affect academic performance. ***Lee,. J. S. (2012).***	Teacher and student relationship is important in emotional and behavioral student engagement.
Study on measuring neural coupling between 3 speakers telling stories and 15 listeners using fNIRS and further compare with fMRI ***Li, Y., et al. (2017).***	1. Neural coupling and synchronization appear in successful communication and absent when communication is blocked. 2. fNIRS can be a useful tool for neural coupling investigation after comparing with fMRI.
Study on mathematic learning and neural activities based on EEG frequency effect ***Skrandies, W. & Klein, A. (2014).***	1. 67%-90% increase in performance is induced by learning rule. 2. The accuracy is determined by the frequency change in EEG and the response time.
Study on investigating frontalpolar INS in social communication and timescale dependency in INS modulation via Japanese cooperative word-chain game ***Nozawa, T. et al. (2016).***	Highest INS level exists in prefrontal region during cooperation communication.
Study on EEG-Based Cognitive Load of 34 participants at multilearning state based on their brain coherence level ***Moona, M, M., Azrina, A., Aamir, S. M. & Hafeez, U. A. (2017).***	1. Alpha wave is the best to measure the cognitive-load in learning. 2. The accuracy of classification increases as the learning state is repeated thrice.

Learning Synchronization



- Wearable Optical Topography is applicable on assessment of Prefrontal Cortex



- Change of oxy-hemoglobin concentration is identified as the activation channel when synchronization take place.
- Change of deoxy-hemoglobin concentration shows no significant change.

Chapter 3

RESEARCH METHODOLOGY

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Tools

Tools	Descriptions
Hitachi HOT-1000 fNIRS	Used to measure the Interpersonal Neural Synchronization level of multiple brains.
MATLAB	Software used to process the data received by fNIRS.
Classroom Setup	Classroom setup is used to demonstrate the experiment for multiple brains hyperscanning. Further detail is discussed in the section of Research Methodology

System Block Diagram

Wearable Optical Topography (WOT)

Data Capturing

Data Processing

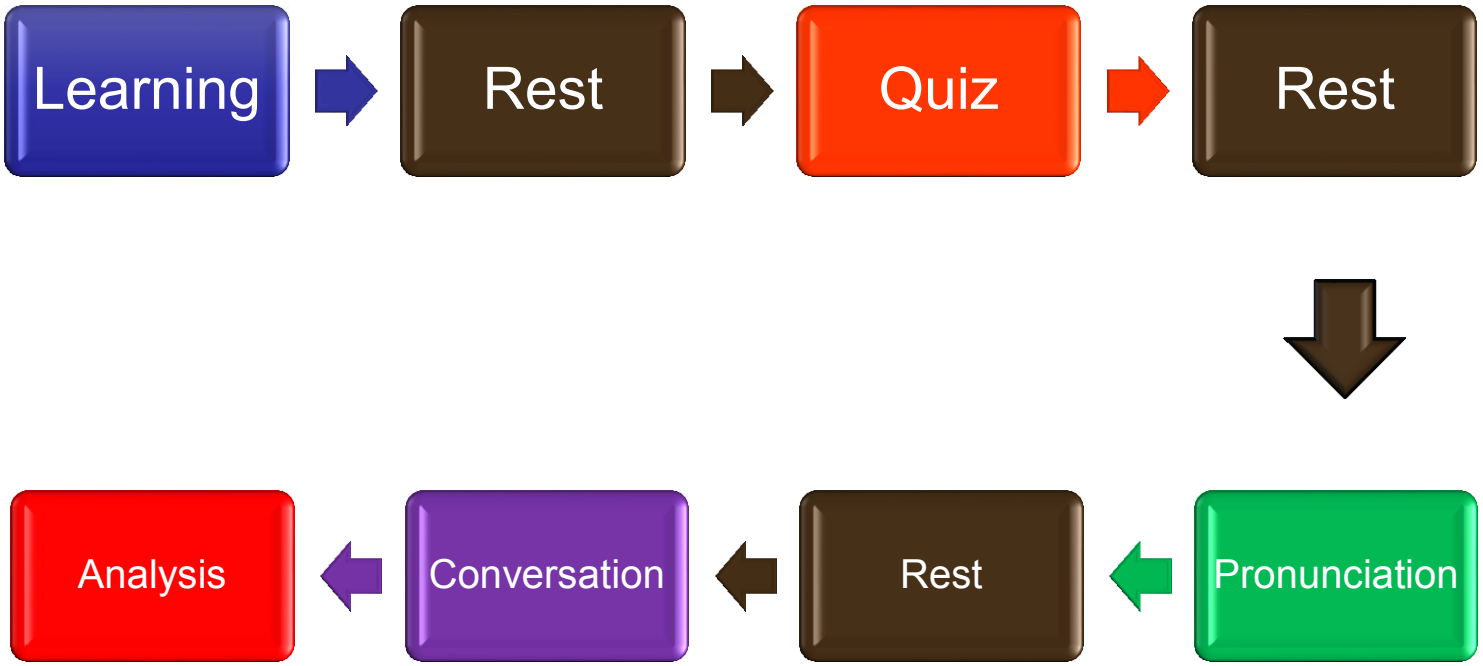
Methodology

Learning a Language		
Requirements		Descriptions
10 Participants	1 tutor	Act as instructor.
	3 experts (Group A)	Students who are able to understand, write and speak the language well.
	3 learners with basic knowledge (Group B)	Students who are only able to write and pronounce the simple words of the language.
	3 new learners (Group C)	Students who do not know anything about the language.

Methodology

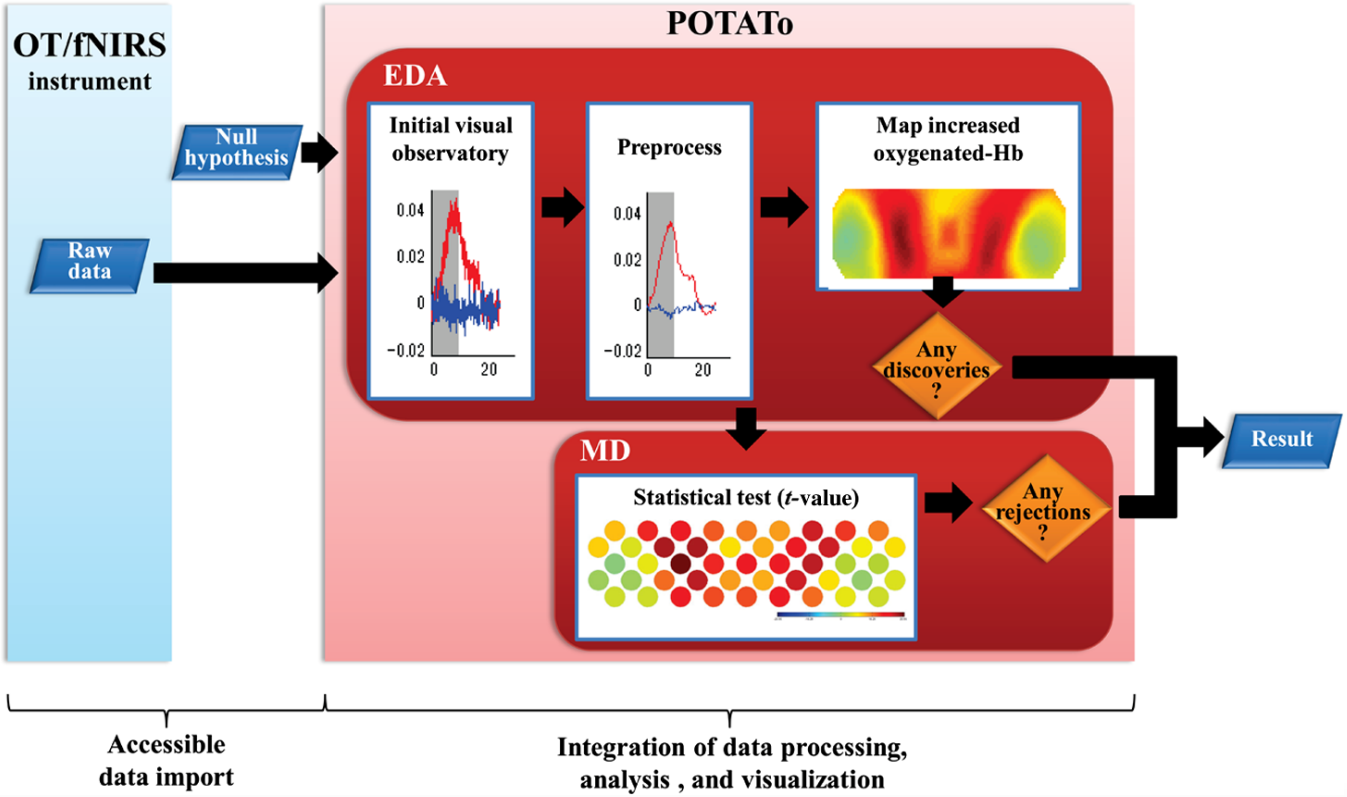
Methods	Tasks	Description
Task 1 (Learning)	Classroom Learning	Learning state will be conducted by the tutors to the 9 participants involved in the classroom.
Task 2 (Answering Question)	Quiz	- Students are required to with answer question paper provided based on different difficulty level - To measure the level of understanding of students based on the response of answering question with different difficulty
Task 3 (Individual Task)	Pronunciation	- Pronounce the words given as much as possible in 1 minute. - To measure students' INS level without any interaction.
Task 4 (Group Task)	Conversation	- Each learner from Group A, B and C communicates with each other by giving script and scenario. - To measure students' INS level during interaction and corporation.
Rest State	Stop activity	- Learners are required to close their eyes and rest for 1 minute. - Aims to help learners to recover their mental state back to normal after each task.

Methodology



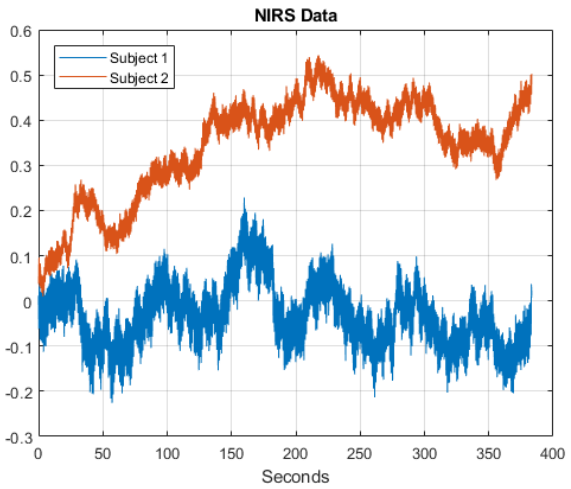
MATLAB
Data Processing

- Software: Platform for Optical Topography Analysis Tools (POTATo)



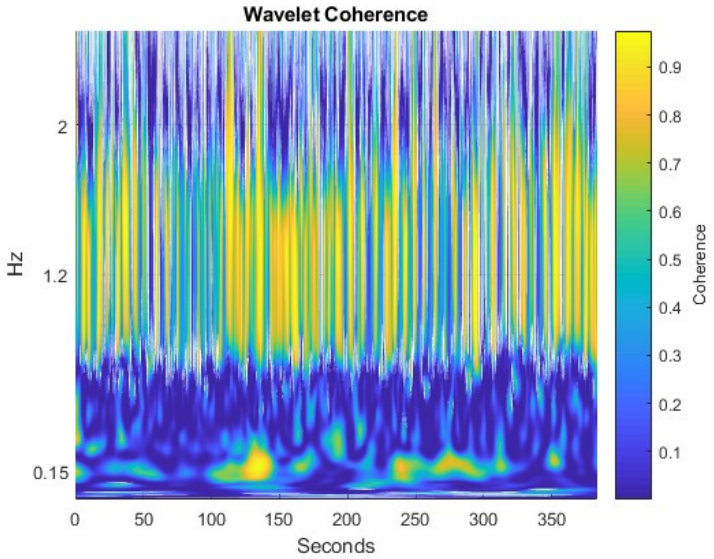
MATLAB Data Processing

- Wavelet Transform Connectivity (WTC)



Time-Domain Data

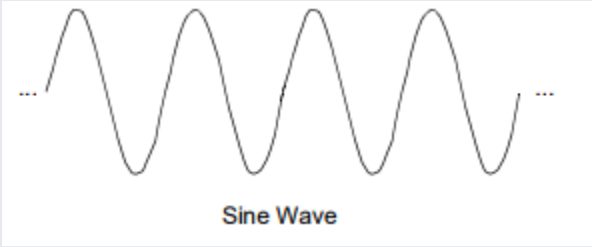
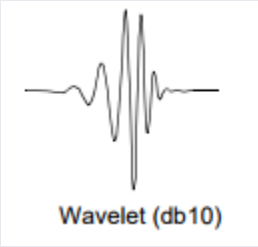
- Data is less clear



Wavelet Analysis Data

- Two-Time Series Coherence Analysis

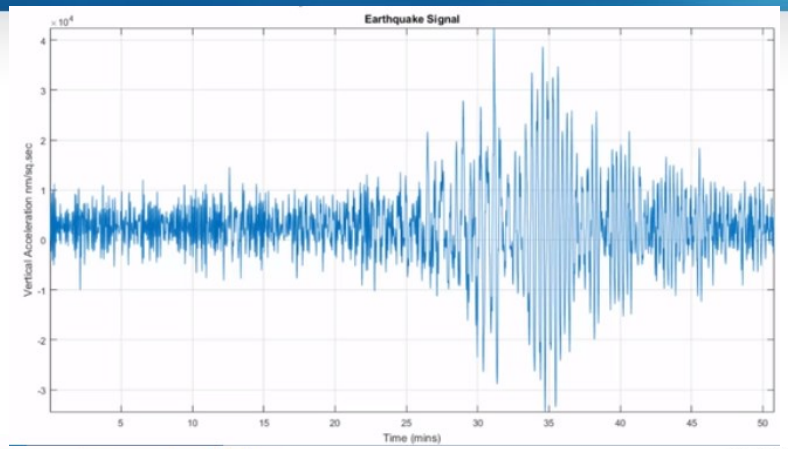
Wavelet Analysis

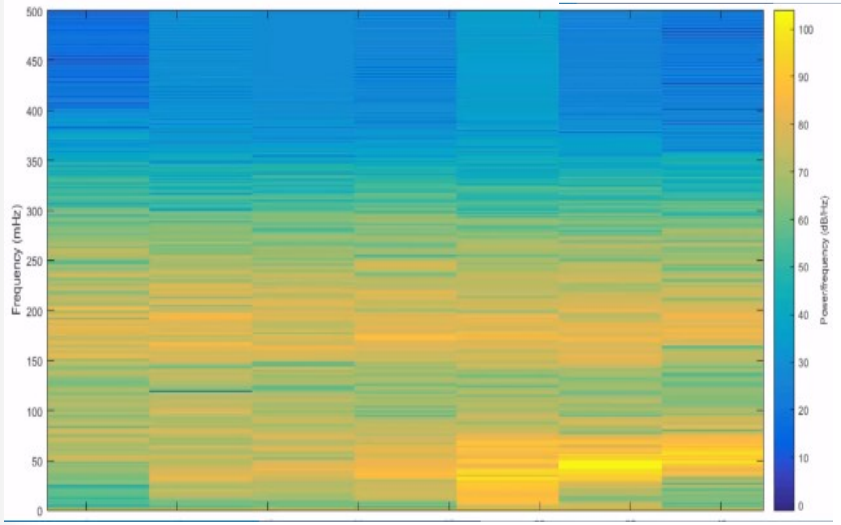
Fourier Transform	Wavelet Transform
When transforming to the frequency domain, time information is lost.	Provides Two-Time Series Data Analysis
Stationary signal	Stationary and non-stationary signal
Not determine local behavior of signal	Perform local analysis
	
Infinite sinewave	Shifted and Scaled (mother) wavelet

Misiti, M., Misiti, Y., Oppenheim, G. & Poggi, J. M. (n.d.). Wavelet Toolbox User Guide.

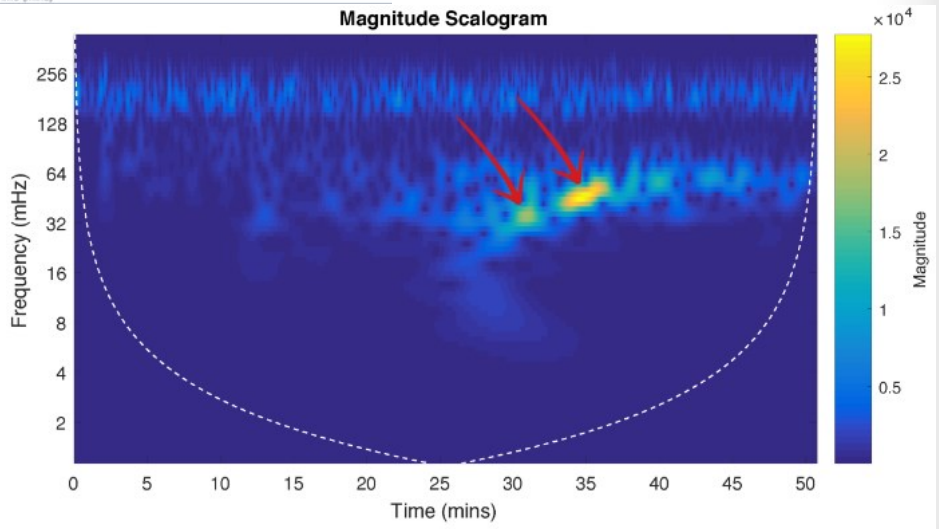
Wavelet Analysis

Time Domain Data





Fourier Transform



Wavelet Transform

Final Year Project Course Milestones

FYP 1 Week	Key Milestone	FYP 2 Week	Key Milestone
1	Final Year Project Title Selection/Proposal	1	Project Continuation
2	Project Detail by FYP Supervisor	7	Submission of Progress Report
5	Project Extended Proposal First Draft	10	Pre-SEDEX
6	Submission of FYP Extended Proposal	11	Submission of Draft Final Report
9	Proposal Defense and Progress Evaluation	12	Submission of Dissertation (soft bound)
12	Interim Report First Draft	12	Submission of Technical Paper
13	Interim Report Draft	13	Viva
14	Project Interim Report Submission	14	Submission of Project Dissertation (Hard Bound)

Project Tasks Milestones

FYP 1 Week	Key Milestone	Objectives
1-4	Literature Review and Feasibility Study	- To study and research on project related journal and article. - To study on project literature review. - To understand about the project setup and prove its feasibility.
5-7	Completion of Protocol Design	- To plan for project methodology and classroom learning layout.
8-9	Completion of Ethics Approval Application	- To present project standard requirement and human right involved to UTP ethics approval panels.
10-11	Completion of Experiment Layout and Materials Setup	- To prepare all materials required for classroom learning setup - To prepare for project in both software and hardware.
12	Completion of Experiments	- To conduct experiments to obtain desired data by using fNIRS.
13	Post-Experiment Review	- To review all data obtained from experiments.
14	FYP2 Preparation	- To prepare for FYP2 for data processing.

FYP 2 Week	Key Milestone	Objectives
1-4	Data Processing	- To analyze the data obtained by using MATLAB
5	Data Validation	- To validate the result by comparing with the predicted result made in the hypothesis
6-7	Debugging & Progress Report Completion	- To figure out the reason of difference between the predicted and experimental result - Complete Progress Report
8	Data Compilation & Final Report Completion	- To finalize and compile all analyzed data to be presentable - Start on Final Report
9-10	Pre-Sedex Preparation & Final Review	- Prepare for Pre-Sedex Evaluation - Final Review of the project before the completion of Final Report
12	Viva Preparation	- Prepare for FYP 2 Viva Presentation

Gantt Chart

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Tasks/Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pre-FYP 1														
Project Title Selection														
Meeting with FYP Supervisor														
FYP 1 Study														
Literature Review Study														
Extended Proposal First Draft														
Extended Proposal Submission														
Feasibility Study														
FYP 1 & Evaluation														
Proposal Defense and Project Evaluation														
Completion of Ethics Approval Application														
Completion of Experiment Setup														
Conduct of Experiment														
Post-FYP 1														
Submission of Interim Report Draft														
Post-Experiment Review														
Submission of Interim Report														
FYP2 Preparation														

Tasks/Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FYP2														
Data Processing														
Data Validation														
Data Debugging														
Data Compilation														
Progress Report Completion														
Submission of Progress Report														
Data Compilation														
Final Report Completion														
Submission of Draft Final Report														
Submission of Draft Dissertation (soft bound)														
Submission of Technical Paper														
FYP 2 Evaluation														
Pre-Sedex														
Project Viva														
Post-FYP 2														
Submission of Dissertation (hard bound)														

Chapter 4

CONCLUSION

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Conclusion

- Students' interaction in the classroom affected their academic performance.
- Optical Topography (OT) System by using fNIRS (HOT-1000) is a potential solution to measure multiple brains interaction to improve learning.
- Hitachi HOT-1000 Portable fNIRS gives advantages in data capturing in a natural environment.
- The results captured will be useful for the research of scientist/engineer to enhance science of learning.

Future Works

Implementation in other learning field such as Engineering, Mathematical and Psychological Learning.

Learning development on new birth.

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End of Presentation

Thank you.

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