CHAPTER 6
NEUROTECHNOLOGY FOR ATTENTION DETECTION

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6.1 INTRODUCTION

The rapid adoption of online learning following the COVID-19 pandemic has significantly reshaped the global education landscape. Higher education institutions in Malaysia initially introduced online learning in the late 1990s. However, it became an essential mode of instruction during the nationwide lockdowns triggered by the pandemic in 2020. In this context, traditional classroom environments were replaced with virtual platforms, compelling both educators and students to quickly adapt to synchronous and asynchronous learning models (Moorhouse, 2020). Synchronous learning mimics conventional classroom settings by enabling real-time interaction through tools such as Zoom and Google Meet. In contrast, asynchronous learning offers greater flexibility, with communication taking place via email, forums, and e-learning platforms, often requiring a higher degree of student autonomy and self-discipline.

Numerous studies have well-documented the advantages of online education, including accessibility, affordability, and flexibility (Ismail and Ling, 2025). However, during the pandemic, many students and educators voiced dissatisfaction with the abrupt transition to online

learning, highlighting issues related to engagement, attentiveness, and reduced interaction (Alan et al., 2020). Despite its many benefits, online learning is plagued by trouble sustaining student attention and assessing engagement. The absence of face-to-face communication limits educators ability to observe non-verbal cues, which are crucial in physical classrooms for adjusting teaching strategies in real time.

While numerous studies have explored student satisfaction and academic performance, few have quantitatively examined attention levels across online and physical learning environments. This study seeks to address that gap by utilising electroencephalogram (EEG) data to measure and analyse students attention in both settings. Specifically, it investigates whether the type of learning environment significantly influences attention span and further explores potential gender-based differences in attentiveness. The research involves data collection from 12 final-year students in a controlled environment, using the Narosky Mindwave EEG device to monitor brainwave activity during sessions on an AI course.

This chapter holds significance for educational institutions in designing optimal learning environments and tools for evaluating student engagement. It also points out the importance of portable EEG for future applications in neurofeedback systems and medical research.

6.2 ATTENTION AND ITS CONVENTIONAL MEASUREMENT

Attention is a core cognitive function that allows individuals to concentrate on a specific task while disregarding irrelevant stimuli and distractions (van Zomeren & Brouwer, 2018). It involves the selective allocation of mental resources to relevant information and is considered a prerequisite for other cognitive processes such as perception, learning, and memory. According to Nobre and Gresch (2025), attention comprises a set of evolved neural mechanisms that facilitate adaptive and effective behavioural responses, highlighting its crucial role in influencing human behaviours. Researchers have

identified several forms of attention, with four principal types commonly discussed:

(1) Sustained attention: Which refers to the ability to maintain focus over time.
(2) Selective attention: Which enables individuals to focus on specific stimuli while ignoring others.
(3) Divided attention: Which allows for processing multiple tasks or stimuli simultaneously.
(4) Executive attention: Which involves the regulation and control of responses in complex or conflicting situations.

In the context of learning, a learner ability to process information effectively is closely linked to their cognitive load, which is influenced by factors such as the complexity of learning materials, how the content is presented, and the learner motivation. Cognitive load theory (CLT) posits that cognitive processing is constrained by the limited capacity of working memory and that excessive or unnecessary cognitive load, such as irrelevant distractions, can impair focus by causing divided attention (Kanokpermpoon, 2019). This divided attention, also referred to as attentional disengagement, can be triggered by both internal and external factors. Internal factors include voluntary shifts in attention, often driven by low motivation or diminished interest in the task, leading learners to mentally disengage Yuldasheva (2025). External factors, on the other hand, typically involve environmental distractions or competing stimuli. Additionally, mind wandering or daydreaming are common internal disruptions that interfere with sustained attention. To systematically evaluate such behaviours, structured observation protocols, such as time sampling, have been employed in various studies (Böheim et al., 2020).

Another widely used approach for assessing attention involves questionnaires and self-report instruments, such as the Conners Rating Scales and the Behavior Rating Inventory of Executive Function (BRIEF). These tools gather comprehensive data from multiple informants, including parents, teachers, and students, to evaluate attention-related behaviours and tendencies. While self-reported surveys