**Research Proposal**

**The Eyes as a Reflection of Systems Thinking: Using Eye-Tracking to Assess Systems Thinking Skills**

**Abstract**

Employment in the 21st century, particularly within the field of engineering, necessitates the adept management and comprehension of intricate processes spanning various disciplines. Engineers operating within dynamic and technologically advanced domains are required to address challenges that demand a profound understanding of systems interactions. Systems thinking, defined as the capability to perceive a system holistically—wherein each component both influences and is influenced by others—facilitates a comprehensive perspective of the system, allowing for the examination of mutual influences over time and space. As global complexity escalates, the imperative to identify and cultivate individuals with systems thinking skills intensifies.

Within this framework, eye-tracking technology presents a novel and compelling approach. Extensively studied from diverse perspectives including psychology, cognitive science, learning processes, and marketing, eye-tracking exhibits significant potential for investigating the correlation between eye movement patterns and systems thinking capabilities. The present research aims to explore the extent to which eye movement data can be leveraged to identify systems thinking, thereby pioneering innovative and creative methods for recognizing and training engineers endowed with systems thinking proficiencies.

**In order to save time and effort later on, and to get the best results from this process, please answer the following questions:**

1. **What is your research question(s)?**
2. **Can eye-tracking technology be used as a reliable diagnostic tool to assess systems thinking ability among engineers?**
3. **Is there a correlation between specific eye movement patterns and systems thinking capabilities?**
4. **Can the use of eye-tracking help in developing new strategies for identifying and training engineers with systems thinking proficiencies?**
5. **Why is the research question important? You may mention other literature in the field, and the expected contribution of your research.**

The research question is important for several reasons:

1. **Lack of Reliable Tools for Assessing Systems Thinking**: Although systems thinking is widely recognized as crucial for effective decision-making and problem-solving in complex environments, there is a scarcity of reliable tools to measure and enhance this skill. Traditional assessment methods, such as questionnaires or self-reports, might not fully capture the cognitive processes involved in systems thinking. Eye-tracking offers a novel approach that could provide more objective and precise insights into these processes.
2. **Contribution to Multiple Disciplines**: The research bridges several fields, including engineering, cognitive science, psychology, and educational technology. By establishing a link between eye movement patterns and systems thinking abilities, this research could contribute to the development of new training methods, improve educational practices, and enhance tools used in psychology and neuroscience to understand cognitive processes.
3. **Innovation in Research Methodology**: Eye-tracking has been extensively used in various domains, such as marketing, human-computer interaction, and psychology, to study cognitive patterns and attention. However, its application in assessing systems thinking is relatively unexplored. This research represents an innovative attempt to apply eye-tracking in a new context, potentially leading to groundbreaking methodologies for evaluating and fostering systems thinking skills.
4. **What are your hypotheses?**

Based on the research proposal, the hypotheses could be formulated as follows:

1. **Hypothesis 1**: **There is a significant correlation between specific eye movement patterns and systems thinking abilities**. Individuals who demonstrate strong systems thinking skills will exhibit distinct eye movement patterns, such as longer fixations on key components and smoother transitions between different elements of a system.
2. **Hypothesis 2**: **Eye-tracking data can accurately differentiate between individuals with high and low systems thinking abilities**. Participants classified as having high systems thinking abilities through traditional assessments (such as questionnaires) will show consistent and identifiable eye movement patterns that differ from those with lower systems thinking abilities.
3. **Hypothesis 3**: **Eye-tracking can be used as a diagnostic tool to assess and improve systems thinking skills**. By analyzing eye movement patterns, it is possible to develop targeted training programs that enhance systems thinking skills in engineers, leading to improved performance in complex, multidisciplinary environments.

These hypotheses aim to explore the potential of eye-tracking technology as a tool for assessing and fostering systems thinking abilities, with the expectation that specific eye movement patterns are indicative of these cognitive skills.

1. **What is the proposed methodology? Why was it selected?**

The proposed methodology involves the following steps:

1. **Participant Selection and Grouping**:

A group of participants will be selected and initially assessed for systems thinking ability using a verbal questionnaire developed by Frank (2010). This assessment will classify participants into two groups: those with high systems thinking abilities and those with low systems thinking abilities.

1. **Visual Questionnaire and Eye-Tracking**:

Participants will then be presented with a visual questionnaire comprising 12 images known to represent characteristics of systems thinking. While viewing these images, participants' eye movements will be tracked using eye-tracking devices such as Tobi lab pro and Tobi pro spark.

1. **Data Collection**:

Eye-tracking data will be collected, focusing on key metrics such as fixation duration, saccades (rapid eye movements between fixation points), and smooth pursuit (tracking of moving objects). This data will help identify patterns that may correlate with systems thinking abilities.

1. **Data Analysis**:

The eye movement data will be analyzed to determine if there is a significant correlation between specific eye movement patterns and systems thinking abilities. Statistical analysis will be used to compare the eye movement patterns of participants with high and low systems thinking abilities.

1. **Pilot Study**:

A pilot study with a smaller sample size will be conducted first to test the methodology and refine the approach. This pilot will involve 10 participants (5 with high systems thinking abilities and 5 with low abilities), where their eye movements will be tracked while they view selected images.

**Rationale for Methodology Selection**

1. **Objective and Precise Measurement**:

Eye-tracking technology provides an objective and precise way to measure cognitive processes, which is crucial for accurately assessing systems thinking abilities. Unlike self-reported questionnaires, eye-tracking captures real-time data on how participants visually engage with complex stimuli, offering insights into their thought processes.

1. **Novelty and Innovation**:

The use of eye-tracking to assess systems thinking is an innovative approach that has not been extensively explored. This methodology allows for the investigation of cognitive patterns that are difficult to measure through traditional methods, potentially leading to new insights and breakthroughs in understanding systems thinking.

1. **Ability to Identify Subtle Differences**:

Eye-tracking technology can detect subtle differences in how individuals process visual information, making it an ideal tool for distinguishing between those with varying levels of systems thinking abilities. This can lead to the development of targeted training interventions aimed at improving these skills.

1. **Comprehensive Data Collection**:

By using both a verbal questionnaire and a visual questionnaire in conjunction with eye-tracking, the methodology ensures a comprehensive assessment of systems thinking abilities. The combination of qualitative and quantitative data strengthens the validity and reliability of the research findings.

1. **Applicability to Real-World Scenarios**:

The methodology is designed to mimic real-world scenarios where systems thinking is required. By presenting participants with complex images that represent system components and interactions, the research simulates the kinds of challenges engineers face in their professional environments, making the findings more applicable and actionable.

1. **What are the main steps that will be involved in conducting your research?**

**The main steps involved in conducting the research are as follows:**

**1. Literature Review**

* **Conduct a comprehensive review of existing literature on systems thinking, eye-tracking technology, and their potential intersection.**

**2. Development of Research Tools**

* + **Develop or adapt a verbal questionnaire to assess systems thinking abilities.**
  + **Prepare the visual questionnaire, consisting of images known to reflect systems thinking traits.**
  + **Configure and test the eye-tracking devices (e.g., Tobi lab pro and Tobi pro spark) to ensure they accurately capture the required data.**

**3. Pilot Study**

* + **Select a small group of participants (10 individuals: 5 with high systems thinking abilities and 5 with low abilities).**
  + **Administer the verbal questionnaire to classify participants.**
  + **Present the visual questionnaire while tracking eye movements.**
  + **Analyze the data from the pilot study to identify any issues with the research process or tools.**

**4. Participant Recruitment**

* + **Identify and recruit a sufficient number of participants who meet the study's criteria.**
  + **Administer the verbal questionnaire to classify participants into those with high and low systems thinking abilities.**

**5. Data Collection**

* + **Present the visual questionnaire to participants while tracking their eye movements.**
  + **Ensure consistent conditions for all participants, including the environment, timing, and sequence of image presentation.**
  + **Record and store eye-tracking data for subsequent analysis.**

**6. Data Analysis**

* + **Use statistical methods to compare eye movement patterns between participants with high and low systems thinking abilities.**
  + **Identify specific eye-tracking metrics (e.g., fixation duration, saccades) that correlate with systems thinking skills.**
  + **Interpret the findings in the context of the research hypotheses.**

**7. Interpretation and Discussion of Results**

* + **Compare the findings with the literature reviewed in the initial stages of the research.**
  + **Discuss the implications of the results for understanding and assessing systems thinking.**
  + **Consider potential applications of the findings in educational and professional settings, particularly in engineering.**

**8. Writing and Submission of Research Paper**