

Analytics of Temporal Patterns of Self-regulated Learners: A Time Series Approach

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Outlines

- Overview of Study.
- Research Gaps.
- Research Questions.
- Methodology.
- Main Findings.
- Discussion.
- Limitations and Future Work.
- Questions.

Temporality in SRL

- What are temporal dimensions?
 - 1) Sequentiality, 2) Passage of time [6].
- Why should we study SRL as temporal processes?

SRL processes are dynamic and change frequently.
- Time-series objective in relation to SRL.

To comprehend and monitor dynamic changes.
- Analytical approaches to studying temporal patterns.

Example: First-Order Markov Model (FOMM) [8].

Research gaps

- **Prior research contributions.**

Examined process transitions, frequencies, and durations [6, 8].

- **Existing gaps.**

- 1) Handling both temporal dimensions from a time-series perspective.

- 2) Shortage of research on detecting SRL strategies based on temporality.

- **How do we intend to fill this gap?**

By employing a time-series approach to detect meaningful strategies.

Research questions

RQ1: What are the learning strategies, and what are the temporal sequences of those strategies, that students enact as they engage in a learning task?

RQ2: To what extent are the learning strategies that learners enact during a task associated with their achievement?

Methodology

- **Participants.**

134 undergraduate students.

- **Study Context.**

Writing an essay using multiple sources using FloRA.

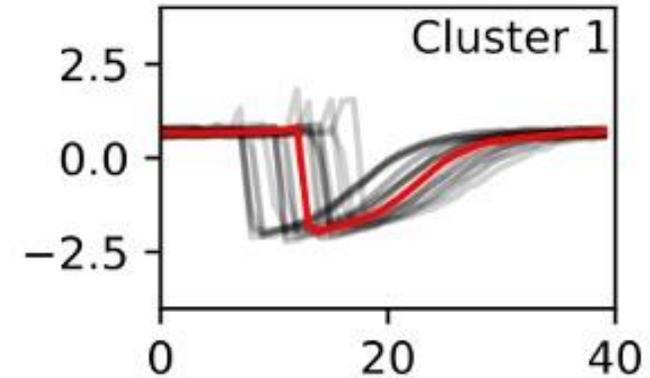
- **Trace Data Measurement.**

Converting the raw trace data into meaningful actions following [2].

- **Data Analysis**

RQ1: Dynamic Time Warping (DTW) technique.

RQ2: ANOVA, ANCOVA.



An example of DTW clustering [3].

Cont. Methodology

- The learning environment.

The screenshot displays the FLORA learning environment interface. At the top left, it says "FLORA My courses". The main content area shows a page titled "1.2 How does AI work?". Below the title, there is a paragraph of text: "Artificial Intelligence always consists of two components: an algorithm and data. In an algorithm a sequence of instructions is programmed that leads to a certain action or result. You can consider an algorithm like a recipe when you are baking a cake. Data is the ingredient that makes the cake. By analyzing more data, the algorithm can make better recommendations. Just like when you have more variety of ingredients, you can make a fancier cake. A key difference between AI and other technologies is that the AI-incorporated systems can learn from the data." To the right of this text, there is a blue arrow pointing to a vertical toolbar labeled "Utility tools".

On the left side, there is a "Catalogue of contents" sidebar. It lists various topics under "1: Artificial Intelligence" and "2: The School of the fu...". The current page "1.2 How does AI work?" is highlighted in blue. A blue arrow points from the text "Catalogue of contents" to this sidebar.

At the bottom right, there is an "Essay Writing Tool" window. It has a title bar "Essay Writing Tool" and "0 words". Below the title bar is a rich text editor with various formatting options (Normal, Bold, Italic, Underline, etc.). The main area of the tool contains the text "Write essay here...". A "Save Essay" button is located at the bottom of the tool. A blue arrow points from the text "Essay writing space" to this tool.

Labels with blue arrows indicate the following components:

- Reading area**: Points to the main text content.
- Catalogue of contents**: Points to the left sidebar.
- Utility tools**: Points to the vertical toolbar on the right.
- Essay writing space**: Points to the "Essay Writing Tool" window.

Cont. Methodology

- The adopted trace data parser [2].

Action patterns

| event | time | raw log | mouse coordinates | Action label | Action pattern |
|-------|---------|---------------------------------------|-----------------------|---------------------|--|
| 1 | 41:09.3 | Start learning environment experiment | | GENERAL_INSTRUCTION | GENERAL_INSTRUCTION* /RUBRIC* -> NAVIGATION -> RELEVANT_READING |
| 2 | 41:09.3 | screen_mouse_click | X: 965, Y coords: 372 | GENERAL_INSTRUCTION | |
| 3 | 42:58.8 | scroll_contentpage_16 | | GENERAL_INSTRUCTION | |
| 4 | 43:34.8 | screen_mouse_click | X: 132, Y coords: 78 | NAVIGATION | |
| 5 | 43:44.6 | nav_content_1.1 | | RELEVANT_READING | |
| 6 | 43:44.6 | screen_mouse_click | X: 149, Y coords: 115 | RELEVANT_READING | |

Mapping



Regular Expression example for this action pattern:
 ((GENERAL_INSTRUCTION)|(RUBRIC))*(NAVIGATION)(RELEVANT_READING)

SRL processes

| event | time | raw log | mouse coordinates | Action label | Action pattern | SRL process |
|-------|---------|---------------------------------------|-----------------------|---------------------|--|-------------------------|
| 1 | 41:09.3 | Start learning environment experiment | | GENERAL_INSTRUCTION | GENERAL_INSTRUCTION* /RUBRIC* -> NAVIGATION -> RELEVANT_READING | MC.O.1 (Orientation) |
| 2 | 41:09.3 | screen_mouse_click | X: 965, Y coords: 372 | GENERAL_INSTRUCTION | | |
| 3 | 42:58.8 | scroll_contentpage_16 | | GENERAL_INSTRUCTION | | |
| 4 | 43:34.8 | screen_mouse_click | X: 132, Y coords: 78 | NAVIGATION | | |
| 5 | 43:44.6 | nav_content_1.1 | | RELEVANT_READING | | |
| 6 | 43:44.6 | screen_mouse_click | X: 149, Y coords: 115 | RELEVANT_READING | | |

Results

- **RQ1:** We detected five meaningful SRL strategies.

Based on metacognitive and cognitive temporal engagement.

The detected SRL strategies:

Cluster 1 -- Incremental Metacognitive Engagement.

Cluster 2 -- Transitional Cognitive Engagement.

Cluster 3 -- Inactive Metacognitive and Occasional Cognitive Engagement.

Cluster 4 -- High Cognitive Engagement.

Cluster 5 -- Consistent Cognitive Engagement.

The plots are available here [link](#).

Cont. Results

- **RQ2: Examined the association between clusters and scores.**
- No statistically significant association was found (p-value = 0.514).
- CET6 English test scores had a statistically significant effect on scores (p-value = 0.005).

| | coef | std err | t | P > t |
|--------------------------|---------|---------|--------|---------|
| Intercept | 4.6123 | 3.351 | 1.376 | 0.172 |
| C(Q("Cluster No")) [T.2] | 0.3031 | 1.081 | 0.280 | 0.780 |
| C(Q("Cluster No")) [T.3] | -0.4434 | 1.166 | -0.380 | 0.705 |
| C(Q("Cluster No")) [T.4] | 0.5606 | 1.253 | 0.447 | 0.656 |
| C(Q("Cluster No")) [T.5] | 0.6865 | 1.135 | 0.605 | 0.547 |
| Q("English CET6") | 0.0170 | 0.006 | 2.849 | 0.005 |

Discussion

- **Providing empirical evidence via a time-series approach.**

Detecting meaningful strategies using temporal patterns of SRL.

- **Our findings aligning with prior studies.**

Example: Students engaged more with cognitive processes to maximize learning [5].

- **Applying multiple techniques provided deeper insights.**

Example: Dividing learners into groups (e.g., high and low) offers deeper understanding.

Limitations and future work

- The language proficiency can lead to varying outcomes.
Replicate this study with recruiting native speakers to compare findings.
- Other factors may impact the detected SRL strategies.
Investigate how factors such as motivation impact SRL temporality.
- The implemented time-series approach could be further enhanced.
By adding adding input features for finer-grained analysis.

References

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Questions

Thank you for your attendance.

