Research Analysis and Integrated System (RAIS): A Web Based Interactive Contents on SPSS Analysis

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ABSTRACT

Many students in Malaysian higher education institution find SPSS data analysis difficult because of their lack of knowledge on theories, unfamiliarity with English terms used in statistics, and difficulties with SPSS user interface. As a result, under normal learning conditions, most students usually just click through different buttons and perform procedural steps rather than gain insight into what the output of the process means. At other times, they adhere to the procedures provided in the handout without fully understand them. Therefore, Research Analysis and Integrated System (RAIS), a web-based tutor that combines pedagogic scaffolding with technology and content, is designed in order to overcome the above issues. RAIS is not meant to provide immediate results of students' work. Rather, using Cognitive Load Theory, Scaffolding, and Zone of Proximal Development, Constructivism, and principles of multimedia learning, RAIS teaches students step-by-step process on how to work within SPSS programs. RAIS features not only provide guidance but are purposely designed to help students comprehend and increase expertise. In the attempt to explain how RAIS is different from other similar solutions, this paper discusses design principles and architecture of RAIS, and its development is clearly theory-driven. In addition, a brief outline of the future design-based pilot study is provided.

Keywords: cognitive load, scaffolding, zone of proximal development, SPSS education, multimedia learning

INTRODUCTION

In college-level courses, it is common for students to undergo at least one academic writing class where they are able to conduct simple research and learn how to present the results. SPSS is a popular statistics tool taught to undergraduates. The five major problems faced by students learning SPSS for statistics are as follows: (1) lack of basic knowledge about statistical principles, (2) trouble handling complicated computer software, (3) language/terminological issues (menus of SPSS are written in English), (4) increased statistics anxiety, and (5) absence of prompt support while having trouble [2]. An example of SPSS output may include large tables filled with numbers that are hard for beginners to understand [1]. Students often become stressed rather than motivated due to those problems [5]. While more or less 79% of learners recognize usefulness of SPSS, most of them find its user interface troublesome from the very beginning (exporting variables, choosing the right test) [1]. In reality, a learner can use an SPSS guide and blindly do the steps without realizing what it means in relation to their research [6]. This mismatch in procedural knowledge and theoretical competence represents one of the major problems because current SPSS teaching does not assist students in comprehending statistical data [6].

Therefore, the problem is clear: beginning statisticians need an integrated approach that helps them cope with both technical and conceptual aspects of SPSS work. Without such an approach, cognitive overload and stress interfere with the process of learning.

There have been various attempts made by educators to apply technological interventions or conduct studies to different aspects of SPSS learning. For example, there could be computer-based lessons or videos demonstrating SPSS operations or online tests assessing knowledge of the corresponding statistics. Still, these approaches tend to be inconsistent and fragmentary, addressing such things as technology, content, and methods separately [3]. Systematic reviews of statistics teaching found out that although most technologies available for statistics teaching provided either practice or demonstration, very few of them provided an integrated process covering data preparation, analysis, and its interpretation [7]. For instance, while 3-D contingent scaffolding model demonstrated how adaptive hints could improve learning hypothesis testing, they were only used for one topic – z-tests [1, 7]. It was revealed by Kao [7] that such contingent scaffolding could greatly enhance students' skills in hypothesis testing if incorporated into computer-based environment, forming strong evidence base for RAIS hint system design.

Despite the presence of some solutions for individual parts of SPSS training, a lack of a consistent "end-to-end" solution that integrates all aspects of SPSS learning persists. Specifically, current solutions fail to integrate immediate and focused help in working in SPSS application. Furthermore, in their study Yu and Liu [12] proved that there was no existing technology offering continuous scaffolding at all stages of analysis; thus, this problem is solved by RAIS system. The integration of SPSS instruction with scaffolding and media-based learning has never been explored before.

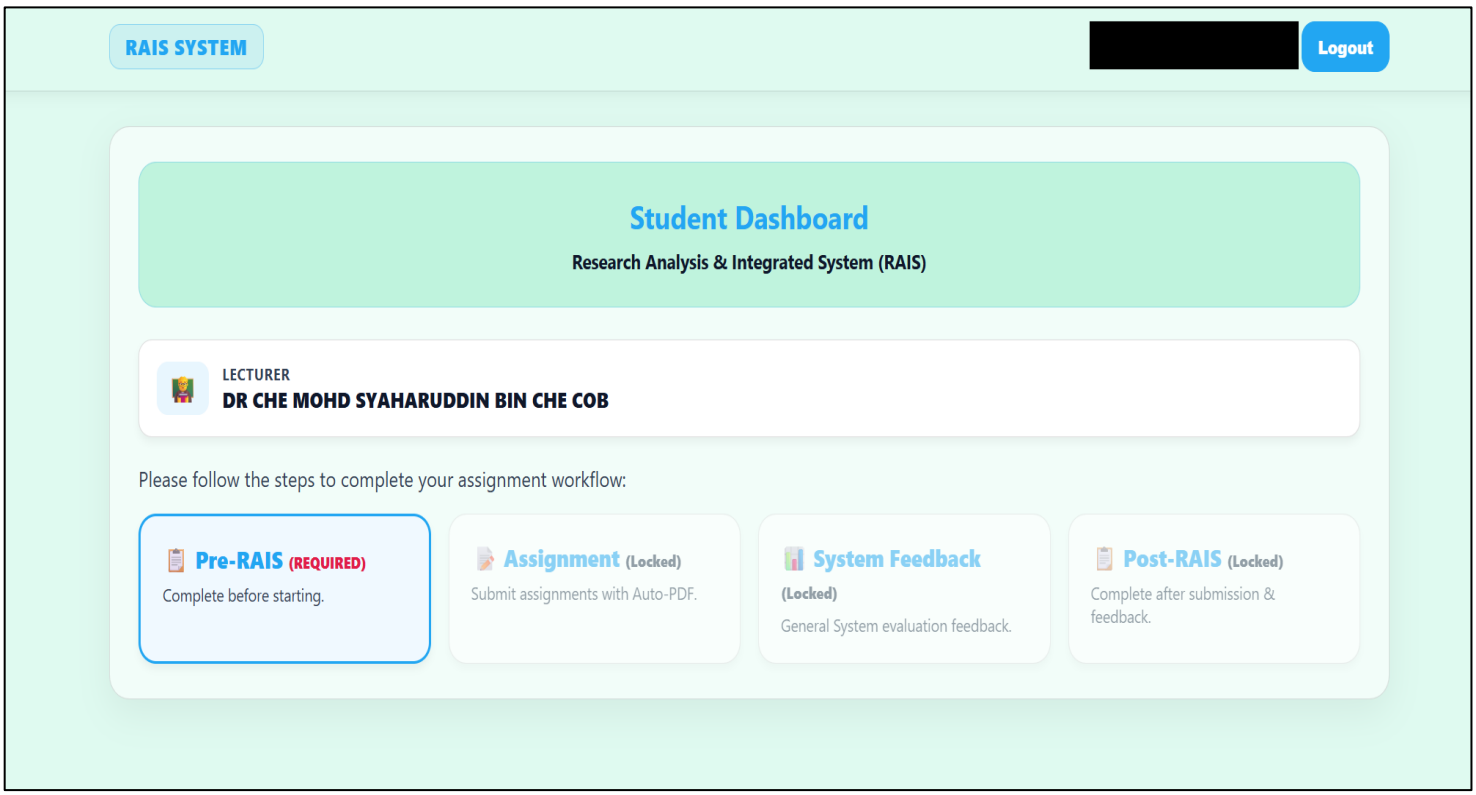


Figure 1. RAIS Interface (Student View)

LITERATURE REVIEW

Rather than listing theories abstractly, we derive functional requirements for RAIS directly from theory:

Cognitive Load Theory (Sweller)

Sweller's Cognitive Load Theory (CLT) states that extraneous cognitive load should be avoided. Design consideration: RAIS adopts an interface that is modular and presents one set of steps at a time. This is achieved through the use of menus that display their options individually along with descriptions, which helps avoid split attention. Moreover, RAIS calculates values ahead of time for students to focus on logic instead of calculations as required by CLT.

Constructivism (Piaget)

The theory of constructivism put forward by Piaget [16] stresses the necessity for individuals to construct knowledge themselves. Design Implication: The RAIS tool is developed in such a way that students have to construct their output, analyze it, and reflect upon it instead of receiving an answer to their question directly. This occurs because the report generator provides students with only a draft to work with.

Scaffolding (Bruner, Wood)

As defined by Wood, Bruner, and Ross [15], scaffolding is the process of helping learners accomplish something that is above their abilities through expert help. The concept holds that learners require gradual fading help. In this regard, RAIS has integrated hints that are both adaptive and fadeable. The theory underpinning RAIS has been the contingent scaffolding model in the 3-D perspective [1]. The system tracks the learner's actions and adapts its actions based on their behaviors. If the learner keeps selecting wrong answers during a test, RAIS gives more obvious hints or examples and when the learner becomes more skilled in the area, the hints become less obvious and may be eliminated completely. In fact, the concept has empirical support in that a meta-analysis done by Jaynes [11] found a big effect size among novice learners in the digital environment.

Zone of Proximal Development (Vygotsky)

The ZPD concept of Vygotsky [17] implies that students are capable of achieving more through assistance. In accordance with this implication, RAIS becomes the "more knowledgeable other" that will never entirely automate an action; it goes side-by-side with the learner. For example, RAIS points out to the empty field in SPSS and tells the learner, "Enter your DV here."

Multimedia Learning (Mayer)

According to the Multimedia Learning Theory (MLT) by Mayer [8, 18], there should be effective dual channel processing which explains why the use of color-coding and annotations in the output interpreter of RAIS is recommended. For example, p-values that are statistically significant will appear in green and associated with audio descriptions of them. The aim here is to reduce extraneous cognitive load while dealing with SPSS "massive tables" [1]. Overall, the RAIS interface applies the principles outlined by Mayer by having visuals accompanied with narration to explain results.

The requirement statements have made it possible for a clear line between the problem, theories, and the design solution by clearly stating theoretical constructs such as "RAIS makes use of fading hints for scaffolding within the ZPD."

METHODOLOGY

In this study, Design-Based Research (DBR) would be used in the creation and development of RAIS system. Van der Stuyf [10] explains that DBR is especially useful in learning technology development, as its essence lies in its ability to undergo repeated iterations in an actual educational setting, which is consistent with the intended process of RAIS development. DBR is an extremely intervention-oriented approach, whose purpose is both pragmatic and theoretical [2]. Most importantly, however, DBR works in repeated iterations based on two processes – analysis and design, followed by implementation and evaluation [9]. This current article reflects the beginning stages of DBR, namely, the Analysis and Design phase, where requirements would be developed through a literature review and research. Subsequent pilot testing would mark the start of implementation and evaluation [2].

RAIS itself would be piloted on a sample group of undergraduates. Methods of data collection would include pre- and post-testing to measure any learning gained, surveys and cognitive load scales to measure effort and anxiety levels, system logs, and focus group interviews to gain student opinions. Data analysis would be done via both descriptive and inferential statistics (paired t-test comparisons between scores on tests before and after use), and qualitative coding of feedback received. All participants would give ethical consent, and all data would be de-identified.

RAIS System Overview

The first deliverable of this cycle is **RAIS**, a modular learning system. Its architecture is depicted in Figure 2, highlighting how each component operationalizes our design principles:

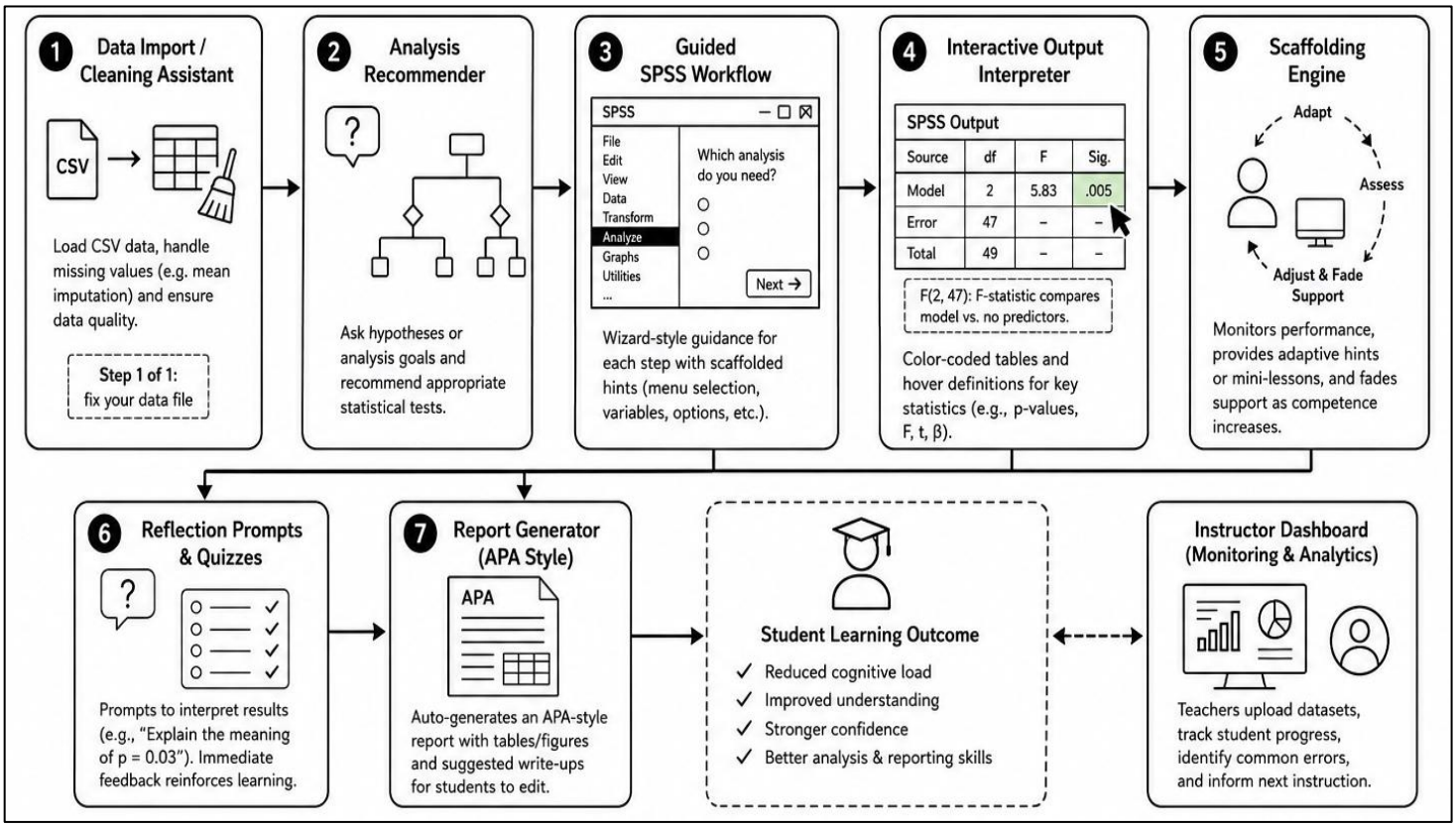


Figure 1. RAIS Architecture: System Flow and Component Interaction

i. In this part, it will be explained what happens at each stage of RAIS process. The Data Import/Cleaning scaffold helps with importing data in CSV format, dealing with missing values (proposing, for example, filling with a mean value), and ensuring high data quality. This beginner scaffold is intended not to make the initial stages of using RAIS discouraging, which is why its first instruction is formulated as follows: "Step 1 of 1: fix your data file."

ii. The Analysis Recommender encourages students to formulate their hypotheses or goals for conducting the analysis. By applying a decision tree algorithm, RAIS offers proper tests (e.g., t-test, ANOVA, regression), thus avoiding wrong choices because of poor understanding of the program. Recent research shows that recommendation of proper analyses improves student self-confidence significantly [1].

iii. The Guided SPSS Workflow presents the SPSS interface via wizards. Each step (selection of the menu item, setting the variables, reviewing options) is followed by scaffolded hints. For example, RAIS suggests to pay attention to the "Analyze" menu and asks: "What analysis should you conduct?" The answer is revealed to the student only after he/she made an attempt, if needed. This interaction significantly decreases cognitive load through focusing on one step per time.

iv. The Interactive Output Interpreter adds explanation to real SPSS output by coloring tables (tables are painted green if the cell contains a p-value less than .05; if not – red). RAIS allows to hover on any statistic in the table and see its explanation (tooltip). For example, hovering over "F(2, 47)" will show "F-statistic compares the model with and without predictors". This way corresponds to Mayer's signaling principle, so students spend less time processing the raw data [4].

v. The Scaffolding Engine works by giving hints to the student when the latter has trouble at a particular stage (such as entering some input incorrectly). When students eventually master this stage, hints are faded out

(remain visible, but are gray). This three-dimensional, contingent scaffolding corresponds to known best practices [1].

vi. Reflection Prompts & Quizzes: After finishing each analysis, RAIS gives reflective tasks like interpreting findings, i.e. asking a student to explain his/her results. For example, RAIS will ask students to interpret p-value: "Why is p = 0.03 meaningful?" Active engagement in learning is achieved by requiring reflection and offering feedback immediately. Such approach leads to internalization of knowledge, rather than its passive perception.

vii. The Report Generator compiles all analyses in APA style (including text, figures, and tables). Students look at the draft report generated by RAIS based on the results and offered write-up, then edit it. Thus, RAIS teaches how reports look formally while providing a material product of students' efforts.

viii. The Instructor Dashboard (not illustrated in the diagram) allows the instructor to provide students with datasets, track their performance, and see typical mistakes. If many students are making the same mistake, for example, mislabeling one of variables, the instructor can amend the following instruction accordingly.

System and Workflow Example

The RAIS approach kicks off this process by stating the research question that guides the entire project: "predict Y from X." For this example, Analysis Recommender suggests using Linear Regression. Using the Guided Workflow approach, RAIS guides the student to click SPSS's Regression menu and continues to guide the clicking of options in SPSS. At this point, the dialog box appears, showing the places for variables where they should be entered. Every step is prompted: for example, RAIS says, "Drag ExamScore into Dependent," ensuring the interaction with the software as opposed to guessing about the correct actions.

After running the analysis, the RAIS Output Interpreter points out the coefficient table, showing the R^2 value in a green cell, indicating that the value is significant. Hovering the cursor over $R^2 = 0.60$ produces the explanation: "60% of the variance in ExamScore is explained by StudyHours." Then comes a reflection prompt: "Is the model significant based on this?" Students respond in the text box provided while the RAIS program supplies the right confirmation message. Last, RAIS adds the results to an automatic report draft like: "Linear regression analysis was conducted. StudyHours significantly predicted ExamScore ($R^2 = .60$, $F(1,18) = 27.00$, $p < .001$),…"

DISCUSSION AND NEXT STEPS

In re-framing each of these theories as features, RAIS creates a closed relationship between pedagogy and technology. The path from theoretical ideas to the methods used to implement the theories is intentional: "To convert these theoretical insights into an implementable approach, we use a Design-Based Research methodology, allowing for iteration based on student interaction" [2]. In the upcoming pilot phase of development, RAIS will be implemented in the context of a course, with results regarding student learning and feedback collected. The current paper describes the analysis and design phases, explaining the motivation behind RAIS design and the criteria – learning outcomes, cognitive load, and student anxiety levels – that will guide future evaluation. With Do Carmo's [13] design framework serving as a guide, the output from each pilot phase can feed directly back into refining RAIS.

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