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Evaluating the User Experience of a "Batch Weight Calculator" in Polymer Laboratory Education Using the UEQ

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ABSTRACT

Students in technical laboratory courses often face difficulty when applying mathematical calculations to practical tasks. In polymer science, batch weight calculation requires several sequential steps involving phr values, density, mixer volume, and fill factor, which may create procedural difficulty for some learners. To address this issue, this study developed a web-based application called the "Batch Weight Calculator" to support batch weight calculation in polymer laboratory activities. The study aimed to evaluate the user experience of the application using the User Experience Questionnaire (UEQ). A total of 59 valid responses from undergraduate polymer science students at UiTM Perlis were analysed after data cleaning. The findings show positive user evaluations across all six UEQ dimensions, with excellent benchmark results in five dimensions: attractiveness, perspicuity, efficiency, dependability, and stimulation. These results indicate that students perceived the application as clear, efficient, and engaging to use. Overall, the study suggests that a lightweight, domain-specific calculation tool may help reduce procedural burden and support a more positive experience in calculation-intensive laboratory work.

1. INTRODUCTION

Students often struggle to transfer mathematical concepts to practical laboratory settings in STEM education, particularly when calculations must be applied within discipline-specific tasks. This difficulty has been discussed in relation to skill transfer, where learners face challenges in recognising connections, recalling relevant prior knowledge, and applying mathematical procedures in new contexts (Eastwood et al., 2011; Gross & Dinehart, 2012). In the transfer skills problem, students struggled to apply mathematics to solve problems in science subjects such as chemistry, biology and polymer. The problem arises because students struggle to recognise connections, recall prior knowledge, and apply mathematics confidently.

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Studies have found that many STEM students have difficulties applying mathematics in science laboratory work. From their perspective, the mathematics in the laboratory is more difficult than the mathematics they learn in mathematics class. Mathematics anxiety has also been associated with reduced confidence and weaker performance in quantitative tasks, which may increase the likelihood of errors during laboratory-related calculations (Zakaria & Nordin, 2008; Khasawneh et al., 2021). In practice, students may turn to digital tools to support calculation-heavy tasks, particularly when they perceive manual procedures as stressful or error-prone (Oviatt et al., 2006; Reis et al., 2012). They believed that these tools, like the spreadsheets, would provide real-time feedback and reduce the pressure associated with complex, error-prone calculations.

In practice, students often rely on either manual calculation or spreadsheet-based workflows to prepare batch formulations. Manual calculation is vulnerable to arithmetic mistakes and repeated recalculation when formulation parameters change. Spreadsheet-based methods reduce some of this burden, but they still require formula construction, cell referencing, and careful checking of intermediate values. In polymer compounding tasks, where the calculations are sequential and interdependent, these additional procedural steps may increase cognitive burden for students who already experience difficulty with mathematical operations. The proposed "Batch Weight Calculator" was therefore designed as a task-specific alternative that automates the relevant calculations directly through a purpose-built interface.

Although spreadsheets can support automation, they may also introduce additional procedural demands because users must manage formulas, cell references, and interface logic alongside the underlying mathematics. In educational settings, interface complexity and split attention can contribute to additional cognitive burden (Mendel & Pak, 2009; Reis et al., 2012; Al-Shehri & Gitsaki, 2010).

This is a new burden to the students and leads to higher error rates, even worse than manual calculations. Therefore, there is a need to explore specialised digital tools designed for narrow laboratory workflows. Such tools may help reduce procedural burden by offloading repetitive calculations and allowing learners to focus more on the scientific task itself, consistent with cognitive load perspectives on instructional support (Van Merriënboer & Sweller, 2010; Joynt, 2024; Paterson, 2019).

This study developed the "Batch Weight Calculator" application, depicted in Fig. 1. This is a specialised web-based application to solve performance-based mathematics anxiety problems. Unlike multi-purpose software, this application is built with a singular focus on the compounding workflow for calculating batch weight. This application provides a clean table-driven interface where students simply list their ingredients, phr values, and densities. The app is written in vanilla JavaScript for maximum compatibility and speed. No server is needed. The application runs in a standard web browser. The application calculates individual batch weights and volumes in real time as the user adjusts the mixer volume or fill factor. The application allows students to see the immediate impact of formulation changes. Hence, this application will make the students focus more on the lab science problem by hiding the difficulty of the mathematics part.

It is important to measure how users feel about an application, in terms of the perceptions of attractiveness, clarity, efficiency, dependability, stimulation and novelty. This study used the user experience questionnaire (UEQ) to evaluate the effectiveness of the "Batch Weight Calculator" application. The UEQ provides a comprehensive assessment of both pragmatic and hedonic qualities. In other words, we can understand how this application impacts the student's emotional state and cognitive perceived workload, especially for students with mathematical anxiety. The questionnaire was distributed to undergraduate polymer science students at Universiti Teknologi MARA Caw. Perlis (UiTM Perlis). The final analysis was conducted on a sample of 59 participants after data cleaning. To determine its efficacy in reducing procedural friction and enhancing student engagement in the laboratory, this study compares the application's performance against a global dataset of 468 products.

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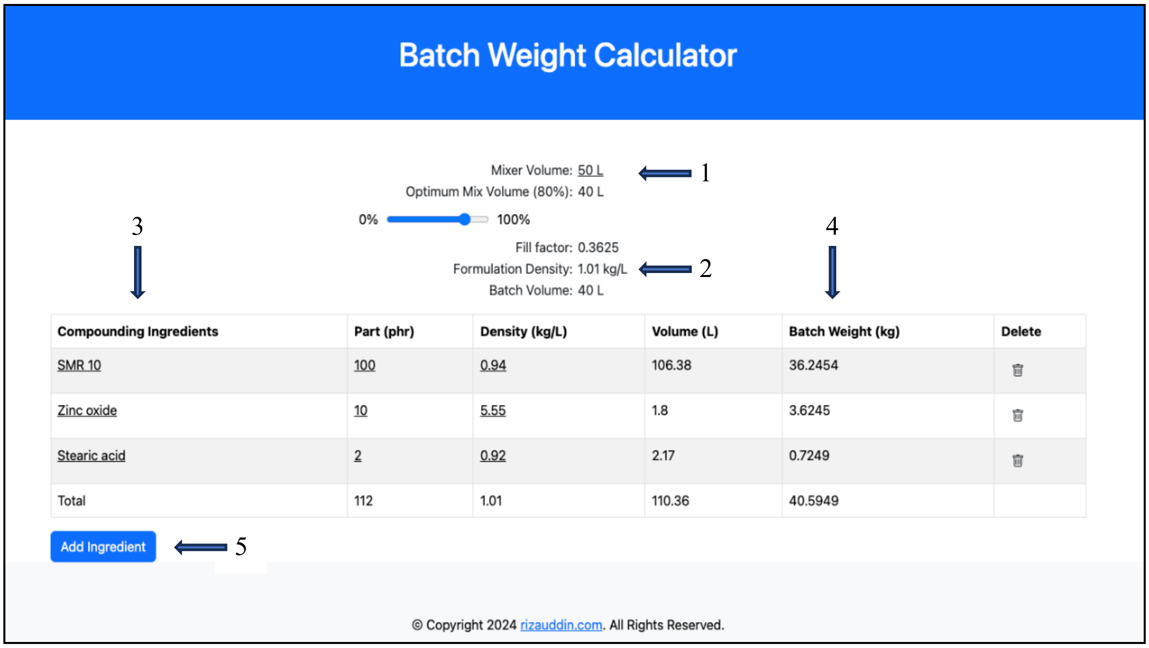

Fig. 1. Annotated interface of the "Batch Weight Calculator" application showing: (1) mixer volume and fill adjustment, (2) real-time formulation summary, (3) ingredient input table, (4) automatically calculated batch weights, and (5) the function for adding formulation components.

The main objective of this study is to investigate user acceptance of the "Batch Weight Calculator" application. Specifically, the study evaluates whether the application provides a positive user experience in batch weight calculation tasks. The specific objectives are to measure its pragmatic quality in terms of efficiency and perspicuity, assess its hedonic impact on student engagement, and benchmark the results against international UEQ standards.

The rest of this paper is structured as follows: Section 2 starts with a review of the existing literature on cognitive load and specialised software. Then, Section 3 explains the development process and evaluation steps. Section 4 presents the results and benchmark analysis. Finally, Section 5 wraps things up with actionable recommendations for future teaching strategies.

2. LITERATURE REVIEW

2.1 Mathematical competence and "skill transfer" in Polymer Science

Most students are confused with units, such as phr (parts per hundred rubber) and weight percentages. Hence, strong mathematics skills are needed to calculate batch weights (Eastwood et al., 2011; Gross & Dinehart, 2012). They often make mistakes with simple arithmetic or typing errors into a calculator. Sometimes, the students faced conceptual errors that led to the wrong formulas (Eastwood et al., 2011; Gross & Dinehart, 2012). Some factories now use automated systems that weigh ingredients precisely to avoid human mistakes (Boger, 2008). They also use gravimetric control, which is a way to double-check that the actual weight matches the math on paper (Ortuño et al., 2020). Companies make sure their products stay consistent and high quality (Luo et al., 2024) by using these tools and methods, such as adaptive sampling.

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Batch weight is a step-by-step process in polymer compounding. Each step requires high precision and accuracy. However, when the student tries to apply mathematics in the theoretical formulation, the calculations become complex.

There are four steps in the calculation to produce the batch weight. First, the student must determine the total phr (P) of the formulation, where the base polymer is always 100 units. Secondly, the student will calculate the theoretical density of the compound (ρ_c) based on the individual densities of each ingredient (ρ_i) as shown in Eq. (1).

$$\rho_c = \frac{\Sigma P}{\Sigma \frac{P_i}{\rho_i}} \tag{1}$$

Once the density is established, the students need to derive the total batch weight (W_{total}) using the mixer volume (V_m) and the fill factor (F). It represents the percentage of the chamber occupied by the material as shown in Eq. (2).

$$W_{total} = V_m \times \rho_c \times F \tag{2}$$

Finally, the student calculates the physical weight of each ingredient (W_i) proportionally using Eq. (3).

$$W_i = \frac{P_i}{\Sigma P} \times W_{total} \tag{3}$$

To illustrate the calculation process, consider a simple formulation consisting of three ingredients: natural rubber (100 phr, density = 0.94 kg/L), zinc oxide (10 phr, density = 5.55 kg/L), and stearic acid (2 phr, density = 0.92 kg/L). Suppose that the mixer volume is 50 L and the selected fill factor is 0.80, giving an effective batch volume of 40 L.

First, the total phr is calculated as:

$$\sum P = 100 + 10 + 2 = 112$$

Second, the theoretical compound density is obtained using Eq. (1):

$$\rho_c = \frac{\sum P}{\Sigma\left(\frac{P_i}{\rho_i}\right)} = \frac{112}{\left(\frac{100}{0.94} + \frac{10}{5.55} + \frac{2}{0.92}\right)} \approx 1.01 \text{kg/L}$$

Third, the total batch weight is calculated using Eq. (2):

$$W_{total} = V_m \times \rho_c \backslash timesF = 50 \times 1.01 \times 0.80 \approx 40.59 \text{ kg}$$

Finally, the batch weight of each ingredient is determined using Eq. (3). For example:

$$W_{\text{rubber}} = \frac{100}{112} \times 40.59 \approx 36.25 \text{kg}$$

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$$W_{\text{zinc oxide}} = \frac{10}{112} \times 40.59 \approx 3/62\text{kg}$$

$$W_{\text{strearic acid}} = \frac{2}{112} \times 40.59 \approx 0.72\text{kg}$$

This example shows how multiple dependent calculations are required before the final batch weights can be obtained. A specialised tool can reduce the need for repeated manual recalculation when any formulation parameter changes.

This sequence is a “dependency chain” for a student. They will produce errors in batch weights if there is a single rounding error or a misinterpreted unit in the density calculation that propagates through every subsequent step. This is the proof that indicates that the lack of competence in mathematical skills in performing a laboratory sequence could produce bad results. It is not due to the skills in polymer, but the mathematics itself.

Research suggests that making math mistakes is a major reason why students fail in STEM laboratories (Kazmierczak & Vander Griend, 2017). In tasks like polymer compounding, a single calculation error can lead to very big mistakes in the final product, with errors ranging from 0.6% to 140% (Pignato & Birnie, 2014).

A student’s math ability and how they think about numbers are the main factors that predict their success in science (Bayaga, 2026; Hananel et al., 2024). Poor math skills caused failures in the lab rather than a lack of science knowledge (Mudit & Alfonso, 2017). In a study, it is found that the schools need to improve math training and show how it is used in real-world lab work in order to supports student success (Mohamed Elsayed, 2022; Patel et al., 2024). Hence, this study developed a web application to address this problem.

2.2 Cognitive Load Theory in STEM lab environments

John Sweller first introduced Cognitive Load Theory (CLT) in 1988 (Sweller, 1988, 2017). It is a famous idea in education that focuses on how our brains process information (Galy & Mélan, 2013). The theory says that our working memory is like a small container that can only hold about five things at one time (Sioradáin & Carr, 2022). To help people learn better, teachers must manage three types of mental effort: intrinsic load (how hard the topic is), extraneous load (distractions or confusing instructions), and germane load (the "good" effort used to store information in long-term memory) (Kalyuga, 2011). By keeping instructions simple and organised, we can ensure the brain has enough room to truly understand and remember new ideas (Al-Shehri & Gitsaki, 2010; Chao et al., 2025; Refat et al., 2020).

Manual batch calculations create a high extraneous cognitive load that competes for the limited mental resources students need for germane load, effectively blocking the construction of long-term schemas in polymer science (Van Merriënboer & Sweller, 2010). The students' memory becomes overwhelmed when they are forced to do tedious, non-essential arithmetic. So, the bandwidth becomes insufficient to process the actual chemical principles or the complex relationships between formulation variables (Miwa et al., 2017; Morrison et al., 2014). The students are merely performing surface-level calculations instead of building a deep understanding of polymer density or fill factors. Hence, it leads to poor retention and higher error rates (Lange & Costley, 2017). To fix this, research suggests using strategies like worked examples or digital tools to "offload" the math, allowing students to redirect their mental energy toward mastering the core scientific concepts (Joynt, 2024; Paterson, 2019).

Recent studies in chemistry education also support the use of digital tools to reduce procedural burden and improve student engagement in laboratory-related learning. For example, digital scaffolds such as task navigators have been shown to support students while solving chemistry tasks by providing structured guidance at the point of need. In addition, newer chemistry learning applications, including augmented

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reality and mobile virtual laboratory tools, have been reported to improve engagement, confidence, and conceptual access in practical learning contexts. These findings suggest that well-designed digital supports can complement laboratory instruction by reducing avoidable procedural difficulty while allowing students to focus on core scientific reasoning.

In a polymer lab, students use a spreadsheet to escape the anxiety of mathematics. However, the student must face a new hurdle. They must learn how to code in a spreadsheet to automate the calculation. The syntax errors in coding the spreadsheet causes secondary source of extraneous load.

The "Batch Weight Calculator" application can act as a calculative scaffold. It hinders the calculations and iterations that are hard. This will ensure that the total cognitive load does not exceed the students' memory limits. As a result, the students will be more confident in the laboratory.

2.3 User Experience and the UEQ framework in education

Evaluating the success of a digital tool in a technical education setting requires a shift from basic usability testing to a holistic user experience (UX) assessment. Traditional metrics, such as the system usability scale (SUS), focus primarily on pragmatic quality. It is the ability of a user to complete a task without errors. However, for students facing mathematical barriers, the hedonic quality, the emotional and psychological impact of the tool, is equally critical. The user experience questionnaire (UEQ) (Laugwitz et al., 2008; Schrepp et al., 2014), addresses this by measuring six distinct scales: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty (Schrepp et al., 2017). It consisted of 26 items and took approximately 3-5 minutes to complete.

Although tools such as SUS are useful for measuring general usability, the present study required a broader evaluation framework. The proposed application was designed not only to support task completion, but also to reduce procedural difficulty and improve student engagement during laboratory calculations. Therefore, UEQ was chosen because it measures both pragmatic quality and hedonic quality, providing a more comprehensive view of the students' experience.

Students will most likely use software that is clear and easy to use in specialised STEM labs. Since they are already stressed by hard tasks like polymer compounding, a confusing screen makes the students reject the application (Bolkan & Goodboy, 2024; Serki & Bolkan, 2024). Research demonstrate that simple and clear tools that require fewer mental effort will make the students focus more on science instead of figuring out the software (Oviatt et al., 2006; Reis et al., 2012). This study used the UEQ to evaluate the "Batch Weight Calculator" application, to see if it is truly helpful or just another distraction as suggested by other researchers (Hinderks et al., 2018; Meiners et al., 2024). This study aims to keep this application simple. A simple and consistent application is the best way to make sure students use it and learn more effectively (Mendel & Pak, 2009).

The stimulation part of the UEQ indicates that making a tool exciting to use can actually help students who feel nervous about math. A calculator with instant feedback will turn a boring or scary math problem into an interactive game where students can explore and learn (Cameron, 2025). This instant win feeling builds their confidence and makes them feel like they are good at science, which helps lower their math anxiety (Khasawneh et al., 2021). These smart digital tools turn lab work into a journey of discovery instead of just counting how many mistakes a student makes (Parvathavarthini et al., 2025). Students are much more likely to use it and stay focused on their goals if we can make the software feel interesting rather than just a chore (Zakaria & Nordin, 2008).

Recent work in chemistry education (Perri, 2020) has explored several types of digital support tools, including spreadsheet-based calculation aids, digital task navigators, virtual laboratories, mobile applications, and augmented reality systems. For example, spreadsheet-supported chemistry activities have been used to support laboratory data generation and calculation tasks, while digital task navigators have been developed as scaffolds to support students during problem solving in organic chemistry. Other studies

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have examined mobile or immersive tools, such as augmented reality and virtual laboratory applications, to support engagement and conceptual understanding in chemistry learning. Collectively, these studies show that digital technologies can support chemistry education in different ways, but they also indicate that most existing tools focus on conceptual visualisation, simulation, or general scaffolding rather than narrowly defined laboratory calculation workflows.

2.4 The research gap

A growing body of work has examined digital applications for science and chemistry education, including virtual laboratories, mobile learning tools, augmented reality environments, spreadsheet-based approaches, and digital scaffolding systems. However, much of this work focuses on conceptual learning, virtual experimentation, or task guidance rather than narrowly defined computational tasks embedded in laboratory workflows. Although spreadsheet-based and calculator-style tools are flexible and widely used in STEM pedagogy, they still require users to construct formulas, manage cell references, or manually verify outputs. In polymer compounding, these additional procedural steps may introduce further difficulty, particularly for students who already struggle with ratio-based calculations and sequential dependency across formulation steps. As a result, limited attention has been given to specialised digital support for polymer compounding calculations, where a single procedural error may propagate through subsequent steps of the formulation process.

Furthermore, while the User Experience Questionnaire (UEQ) has been widely used to evaluate commercial software and general e-learning platforms, its application to targeted laboratory tools for students with mathematical difficulty remains limited. Existing studies in this area often emphasise functional accuracy, task completion, or basic usability rather than a broader user experience perspective that includes pragmatic quality and hedonic quality. Consequently, there is a need not only for specialised tools that support real-time laboratory calculation, but also for evaluation approaches that examine how such tools are perceived by learners in authentic educational settings.

This study addresses these gaps by evaluating a lightweight, domain-specific "Batch Weight Calculator" designed for polymer laboratory use. The contribution of the study lies not in digital calculation alone, but in the design and user experience evaluation of a specialised tool that supports real-time compounding calculations, reduces spreadsheet-related procedural burden, and is intended for students facing mathematical difficulty in laboratory settings.

3. RESEARCH METHODOLOGY

The development and evaluation of the "Batch Weight Calculator" application followed a structured waterfall methodology. This linear-sequential model was selected because the mathematical requirements of polymer compounding are grounded in established chemical principles, meaning the functional specifications remained stable and well-defined throughout the project lifecycle.

3.1 Requirement analysis

Initially, this study identifies the difficulties in the calculation steps of the batch weight faced by polymer science undergraduates using observation and consultation with the laboratory instructors at UiTM Perlis. The analysis indicated that the primary difficulty is in the sequential dependency of the compounding formula. Then, the requirements were set to develop a tool that could perform the four tasks. The first task is to automate the conversion from theoretical phr to physical mass (kg). The second task is to handle theoretical density calculations for complex mixtures. The third task is to adjust batch sizes dynamically based on mixer volume and fill factor. The fourth task is to provide a zero learning curve interface for math-anxious users.

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3.2 System design

The application was designed as a single-page web interface so that all key inputs, controls, and outputs remained visible within one continuous workflow. Beyond the general single-page application (SPA) structure, the system was organised into four main functional components: (1) an ingredient input module, (2) a mixer parameter module, (3) a calculation engine, and (4) an output display module.

The ingredient input module allows users to enter formulation components together with their corresponding phr values and densities. The mixer parameter module captures global formulation settings such as mixer volume and fill factor. These input values are passed to the calculation engine, which applies the batch weight equations to compute the total phr, theoretical compound density, effective batch volume, and the batch weight of each ingredient. The output display module then presents the calculated values directly within the same interface, enabling the user to review results without moving to another screen.

The workflow of the application is sequential but reactive. When a user modifies any ingredient value or mixer parameter, the calculation engine updates the dependent values immediately and propagates the results throughout the formulation table. This design supports the interdependent nature of polymer compounding calculations, where a change in one parameter may affect all subsequent outputs. By keeping the input, computation, and output processes tightly integrated within one screen, the system was designed to reduce navigation burden and support clarity during laboratory use.

3.3 Implementation

The "Batch Weight Calculator" was implemented as a lightweight client-side web application using HTML5, CSS3, and vanilla JavaScript. No external front-end frameworks, backend services, or database systems were required, as all calculations were performed locally in the user's browser. This approach supported portability and reduced deployment complexity in the intended educational setting.

To improve reliability during use, the application incorporated basic input handling and validation for key numerical fields, including phr values, density, mixer volume, and fill factor. Invalid or incomplete values were not passed directly into the calculation routine, thereby reducing the likelihood of propagating incorrect outputs across dependent formulation fields.

The calculation workflow was implemented through browser-side event handling. When a user modified any formulation value or mixer parameter, the relevant outputs were recalculated immediately within the same interface. Because the application relied only on lightweight arithmetic operations and did not require server communication, the system remained responsive for real-time recalculation during laboratory tasks.

Basic functional testing was also performed using representative formulation cases to verify that the implemented equations produced consistent results for total phr, theoretical compound density, total batch weight, and ingredient-level batch weights. Where applicable, the outputs were checked against reference calculations to support reliability before classroom use.

3.4 Evaluation framework (with UEQ)

The evaluation involved undergraduate students from the Polymer Science programme at UiTM Perlis who were enrolled in a laboratory module requiring compounding-related calculations. Formal ethics approval was waived for this study. Nevertheless, standard ethical procedures for educational research were followed. Participation in the evaluation was voluntary, and the students were informed of the purpose of the study, the nature of the questionnaire, and their right to decline participation without penalty. Informed consent was obtained before the UEQ responses were collected. The responses were analysed anonymously, and no personally identifying information was included in the final dataset. All data were treated confidentially and used solely for research purposes.

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The evaluation was conducted in a controlled laboratory setting. Before completing the questionnaire, the students used the application during a laboratory-related calculation activity involving formulation inputs such as phr values, density, mixer volume, and fill factor. A brief introduction to the interface and purpose of the application was provided before use. The UEQ was administered immediately after the activity in order to capture the students' direct experiential response to the application. Each participant used the tool during a single session lasting approximately 5 minutes.

The UEQ was selected because this study aimed to assess not only task-related usability, but also the broader experiential qualities of the application. Since the "Batch Weight Calculator" was intended to support clarity, reduce procedural burden, and encourage engagement during calculation-intensive laboratory work, an instrument covering both pragmatic quality and hedonic quality was considered more suitable than a narrower usability-focused scale.

Initially, 65 responses were collected. The data were then screened using the built-in inconsistency check in the UEQ Data Analysis Tool, which identifies contradictory responses to semantically related item pairs. Six response sets were excluded based on this procedure. Therefore, the final analysis was conducted using 59 valid responses.

4. RESULTS AND DISCUSSION

4.1 UEQ scale results

The data collected from the 59 participants were analysed across the six UEQ scales. They are the undergraduate students in the Polymer programme at UiTM Perlis. All scales are interpreted using Schrepp's (2014) guideline, where values > 0.8 indicate positive evaluation, values between –0.8 and 0.8 indicate neutral, and values < –0.8 indicate negative evaluation. The results indicate a strong positive reception of the "Batch Weight Calculator" application. Table 1 summarises the mean scores, variances, and standard deviations for each scale.

Attractiveness reflects the users' overall impression of the application. The mean score of 1.944 indicates a strongly positive evaluation, suggesting that students generally found the application pleasant, appealing, and satisfactory to use. The confidence interval (1.695 to 2.192) lies fully within the positive range, confirming the stability of this perception across respondents. This result demonstrates that the application is well accepted by students at an overall experiential level.

Table 1. Mean scores of the UEQ scales (N=59)

UEQ Scale	Mean	Variance	Std. Dev.
Attractiveness	1.94	0.95	0.95
Perspicuity	1.91	1.11	1.05
Efficiency	1.92	1.33	1.1
Dependability	1.63	1.03	1.02
Stimulation	1.85	0.98	0.99
Novelty	0.81	1.73	1.31

Perspicuity measures how easy it is to understand and learn how to use the system. With a mean of 1.907, students perceived the "Batch Weight Calculator" application as clear, understandable, and easy to get familiar with, which is particularly important in a laboratory context where time and accuracy are

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critical. The positive confidence interval (1.638 to 2.175) indicates consistent agreement among users, suggesting minimal learning difficulties.

Efficiency evaluates whether users can complete tasks quickly and with minimal effort. The mean score of 1.924 reflects a highly positive perception of efficiency. This implies that the application effectively supports students in calculating batch weights without unnecessary steps or delays. Given that laboratory work often involves repetitive calculations, this high efficiency score confirms that the application meets its functional purpose well.

Dependability refers to users' sense of control, predictability, and reliability when interacting with the system. The dependability score of 1.631, while slightly lower than other pragmatic scales, still falls well within the positive evaluation range. This indicates that students generally trusted the system and felt in control when using it, although this dimension could potentially be further improved compared to efficiency or clarity.

Stimulation captures whether the application is exciting, motivating, and enjoyable to use. A mean value of 1.852 indicates that the application provides a positive and engaging experience, even though it is primarily a functional laboratory tool. This suggests that the application does more than merely support task completion. It also keeps users interested and motivated.

Novelty measures perceived creativity and innovativeness. The mean score of 0.814 is just above the positive threshold, indicating a marginally positive evaluation. Compared to other scales, novelty is the lowest-rated dimension, suggesting that while the application is useful and usable, students may perceive it as more functional than innovative. This is common for academic or utility-based applications where practicality is prioritised over originality. The results show that the pragmatic qualities, the perspicuity (1.91) and efficiency (1.92), received very high ratings.

This suggests that the application successfully met its primary design goal: providing a clear and fast way to calculate batch weights without procedural confusion. The high attractiveness (1.94) score further indicates that the overall impression of the tool was highly favourable, which is critical for overcoming the initial resistance often seen in math-anxious learners.

4.2 Pragmatic and hedonic quality

The scales of the UEQ can be grouped into two types. The first is the pragmatic quality that consists of Perspicuity, Efficiency and Dependability. Pragmatic quality describes task-related quality aspects. The second is the hedonic quality that consists of Stimulation and Originality. Hedonic quality describes the non-task-related quality aspects.

Pragmatic quality combines Perspicuity, Efficiency, and Dependability, representing task-related aspects of user experience. The high score of Pragmatic Quality Mean (1.82) indicates that the "Batch Weight Calculator" application performs very well in supporting users' task goals, particularly in terms of clarity, speed, and reliability. The result aligns strongly with the application's intended purpose as a laboratory calculation tool. Overall, students perceive the system as effective, practical, and easy to use, which is essential in an educational laboratory environment.

Hedonic quality is derived from Stimulation and Novelty, reflecting non-task-related aspects such as enjoyment and innovation. The score of Hedonic Quality Mean (1.33) indicates a positive but comparatively moderate hedonic experience. Students found the application enjoyable and somewhat stimulating, but less innovative compared to its pragmatic strengths.

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4.3 Overall user experience interpretation

Overall, the UEQ results demonstrate that the "Batch Weight Calculator" application delivers a very positive user experience, particularly in terms of pragmatic quality. All six UEQ scales fall within the positive evaluation range, with no neutral or negative dimensions observed.

(i) Strongest aspects: Attractiveness, Efficiency, Perspicuity.

(ii) Adequate but improvable aspect: Novelty.

(iii) Overall UX profile: Highly usable, reliable, and well accepted, with sufficient hedonic appeal for an educational tool.

From the survey, it was found that the application has successfully supported undergraduate students in laboratory settings by providing a clear, efficient, and dependable user experience, while also maintaining a satisfactory level of stimulation and engagement.

4.4 Discussion and implications

Among the six UEQ dimensions, novelty received the lowest mean score, although it still remained within the positive evaluation range. This pattern suggests that students perceived the application as functional and useful, but not especially innovative or visually distinctive. One possible reason is that the interface was intentionally designed in a utilitarian and table-oriented manner so that users could focus on calculation tasks with minimal distraction. Such a design may support clarity and efficiency, but it may also reduce the sense of originality or excitement typically associated with higher novelty ratings. In this context, the lower novelty score should not be interpreted simply as a weakness, but rather as a reflection of the design trade-off between familiarity and innovation. Future interface refinement could therefore focus on moderate enrichment, such as clearer visual hierarchy, more polished feedback cues, or improved interactive affordances, while preserving the simplicity that contributed to the strong perspicuity and efficiency results.

Although the present study did not include a controlled experimental comparison with manual calculation or spreadsheet-based workflows, the UEQ findings offer a useful basis for discussing the practical advantages of the application. The high scores for perspicuity and efficiency suggest that students perceived the tool as easier to understand and faster to use than more general computational approaches typically employed in laboratory preparation. Unlike manual calculation, the application supports immediate recalculation when formulation inputs are changed. Unlike spreadsheets, it does not require users to construct formulas, manage cell references, or troubleshoot table logic. These characteristics are especially relevant in polymer compounding, where a procedural error at an early stage may affect all subsequent results. Nevertheless, because the present study measured user experience rather than objective task performance, these practical advantages should be interpreted as perceived benefits rather than experimentally verified superiority.

Although the present study did not include a controlled comparison with manual calculation or spreadsheet-based workflows, it is still useful to position the proposed application against these commonly used approaches in polymer laboratory practice. Table 2 presents a conceptual comparison based on workflow characteristics relevant to batch weight calculation. This comparison is intended to clarify the practical role of the "Batch Weight Calculator" rather than to claim experimentally verified superiority.

As shown in Table 2, the proposed application is positioned as a domain-specific alternative to more general calculation methods. Its main practical advantage lies in reducing procedural overhead during formulation work by removing the need for manual re-computation or spreadsheet formula management. This interpretation is broadly consistent with the high perspicuity and efficiency scores obtained in the UEQ evaluation. However, because the present study did not directly compare performance outcomes across

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methods, these observations should be interpreted as conceptual and experience-based rather than as evidence of objective superiority.

Table 2. Conceptual comparison of common calculation approaches in polymer compounding tasks

Approach	Strengths	Limitations in polymer compounding context
Manual calculation	No software required; conceptually transparent	Error-prone; repetitive recalculation; time-consuming when formulation parameters change
Spreadsheet	Flexible; familiar; supports automation	Requires formula setup, cell referencing, and troubleshooting; may impose additional procedural burden
Batch Weight Calculator	Task-specific; real-time recalculation; direct workflow mapping to phr, density, mixer volume, and fill factor	Limited to a narrow application domain; not yet comparatively tested against other methods

5. CONCLUSION

5.1 Summary of findings

This study used the User Experience Questionnaire (UEQ) to evaluate the "Batch Weight Calculator" application, a specialised digital tool developed for polymer science education. The evaluation involved 59 valid participant responses. The application received excellent benchmark ratings in five dimensions, namely attractiveness, perspicuity, efficiency, dependability, and stimulation. These findings indicate that students perceived the application as clear, efficient, and engaging to use during batch weight calculation tasks. Overall, the results suggest that the application has potential to reduce procedural difficulty and support a more positive laboratory experience in calculation-intensive activities.

5.2 Pedagogical and industrial implications

The findings suggest that the "Batch Weight Calculator" application may serve as a useful form of calculative scaffolding in polymer laboratory education. By automating procedural arithmetic, the application may help reduce unnecessary calculation burden and allow students to focus more on the underlying scientific aspects of the task. In this sense, the tool has pedagogical value as a support mechanism for calculation-intensive laboratory activities, particularly for students who may experience difficulty with sequential formulation calculations.

From a broader perspective, the study also highlights the potential role of lightweight, domain-specific digital tools in bridging educational practice and technology-supported professional workflows. Although the present study did not directly assess learning outcomes or industrial performance, the positive user experience findings suggest that such tools may support more efficient and structured laboratory preparation. This is relevant in technical and industrial contexts where procedural accuracy and responsiveness are valued.

5.3 Limitations and future work

This study has several limitations. First, the evaluation was conducted using a single cohort of undergraduate students at UiTM Perlis within a specific polymer laboratory context. Therefore, the findings may not be generalisable to other institutions, disciplines, or learning environments. Second, the study did not include a control condition or direct comparison with manual calculation or spreadsheet-based

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workflows. Accordingly, the findings should be interpreted as evidence of perceived user experience rather than objective proof of superiority in terms of accuracy, speed, or learning performance.

Future work should involve broader samples across other UiTM campuses or additional institutions to improve generalisability. It should also incorporate controlled comparative evaluation to determine whether the proposed tool improves calculation accuracy, reduces completion time, or supports learning more effectively than traditional methods. In addition, future studies may examine the application using other UX instruments, such as the System Usability Scale (SUS), AttrakDiff, or the Standardised User Experience Percentile Rank Questionnaire, to provide complementary perspectives on its performance. Further development may also include features such as a history log or cloud persistence so that students can track their formulation progress across multiple laboratory sessions.

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7. CONFLICT OF INTEREST STATEMENT

The authors declare that they have no personal, commercial, or financial conflicts of interest, and that no conflict of interest exists with the funders.

8. AUTHORS' CONTRIBUTIONS

Rizauddin Saian: Conceptualisation, Application development, Formal analysis, Writing original draft**;** **Mohd Syamaizar Mustafa:** Conceptualisation, Validation, Subject-matter expertise**;** **Nadia Abdul Wahab:** Methodology, Data curation, Formal analysis**;** **Khairu Azlan Abd Aziz:** Editing, Visualisation, Manuscript preparation**;** **Nor Mazlina Abdul Wahab:** Validation, Subject-matter expertise**.**

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