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Integration of Indigenous Knowledge Systems and Practices (IKSP) in Undergraduate Biochemistry Education: Implications for Student Comprehension and Learning Retention

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Abstract

This study examined the effectiveness of Indigenous Knowledge Systems and Practices (IKSP) compared to traditional teaching methods in undergraduate biochemistry education. The research focused on student comprehension and knowledge retention over different time frames. Results showed that the IKSP method demonstrated superior immediate effects, with a 60.6% increase from pre-test to post-test, compared to the traditional method's 34.2% increase. However, the traditional method exhibited better short-term retention. Interestingly, after two weeks, the IKSP method outperformed the traditional method in long-term retention, indicating that each method's effectiveness varies depending on the testing timeframe. While the traditional method showed more consistency in immediate application, the IKSP method led to more uniform performance in the long run, particularly in retention. Time and the interaction between time and teaching method were strong predictors of student achievement, explaining 62.5% and 18.6% of the variance, respectively. Based on these findings, the researchers recommend: Integrating both IKSP and traditional methods to leverage their respective strengths at different stages of the learning process; Developing strategies to enhance short-term retention for the IKSP method and long-term retention for the traditional method; and, Implementing continuous evaluation of student progress to optimize adaptive teaching strategies that balance immediate effectiveness, short-term retention, and long-term performance consistency. This study highlights the importance of considering temporal factors in educational method effectiveness and suggests a hybrid approach to maximize learning outcomes in undergraduate biochemistry education.

Keywords: Biochemistry, Science education, Classroom setting, Indigenous practice

INTRODUCTION

Indigenous knowledge systems and practice are better valued in contemporary educational contexts for their enriching potential of learning outcomes and making them culturally more relevant (Smith, 2020). This growing appreciation is founded on the realization that traditional knowledge systems often encompass useful insights that complement and further the evolution of current scientific knowledge (Williams & Brown, 2019). This has an excellent chance of being realized under the integration of IKSP into science education, more specifically biochemistry, since it will bring together traditional wisdom and current scientific paradigms (Johnson et al., 2021). In the case of biochemistry, the place of IKSP within educational sciences has been outstanding since it makes available a great opportunity to be able to link traditional knowledge with modern scientific paradigms.

On the other hand, the role that biochemical education takes in the development of learners' understanding of life at molecular levels is very pivotal in preparing them for science careers. Although so, traditional pedagogies within the biochemistry classroom have usually failed to engage students fully and promote long-lasting knowledge retention. In the last couple of years, there has been a growing interest in the integration of diverse knowledge systems in science education; more specifically, the emphasis is that IKSP should be able to foster student learning and culturally inclusive implementation in science classrooms.

Correspondingly, biochemistry education can help students realize the molecular explanation of life and prepare students to seek employment in science-related aspects. However, traditional ways of teaching biochemistry fail to engage students fully and promote long-term knowledge retention for the students (Wood, 2009). Over the past couple of years, there has been a growing interest in the integration of diverse knowledge systems into science education; in particular, Indigenous Knowledge Systems and Practices have drawn major attention, with the key view of establishing enhanced student learning outcomes alongside cultural inclusivity (Snively & Coriglia, 2001).

Another example is the need to include IKSP in biochemistry, which shifts toward the broad view of science teaching. Indigenous knowledge substantially supports this approach and probably improves students' levels of understanding and retention in complex sciences (Garcia-Lopez & Hernandez, 2022). Making connections between abstract biochemical concepts and relevant applications in cultural environments will increase students' understanding of the subject matter at hand (Thompson, 2018). Indeed, IKSP are holistic ways of understanding the natural world that include traditional ecological knowledge and cultural practices, together with their related spiritual beliefs (Mazzocchi, 2006). Such systems have evolved over generations and thus can provide a unique understanding into biological processes and environmental interactions. This could eventually equip students with much broader and more culturally relevant knowledge about the molecular life sciences when IKSP is integrated into biochemistry education (Gondwe & Longnecker, 2015).

It has been evidenced that IKSP incorporation can lead to improved learning outcomes across many scientific disciplines. For instance, one study by Lee and Park in 2023 showed that students in biology courses integrating traditional ecological knowledge displayed significantly greater levels of class engagement and conceptual understanding compared with students in traditional courses. On the contrary, from the aspect of teaching chemistry, Rodriguez et al. (2022) put it across that learners who were exposed to indigenous learning methodologies in understanding chemical reactions exhibited enhanced problem-solving abilities.

Some researches have therefore been supplying proof that there is a positive gain when traditional knowledge is integrated in science education. According to some information, Kimmerer, (2002) involved traditional ecological knowledge in curriculum content of environmental science courses and discovered an improved engagement and critical thinking skills. Equally, Aikenhead, (2001) reported learning gains for Indigenous students with culturally responsive science teaching methods.

Within a biochemistry teaching and learning context, IKSP would have many advantages. As one example, traditional medicinal practices are often based on biochemical processes that are quite complex and thus can be used to illustrate basic concepts about enzyme kinetics, metabolic pathways, or natural product chemistry (Etkin, N. L. 1988). These food preservation techniques can be directly applied to many indigenous, real-life examples of protein denaturation, microbial growth inhibition, and oxidation reactions (Tamang, J. P., Cotter, Endo, Han, Kort, Liu, & Hutkins, 2020).

This would fall within the larger initiative of decolonizing science education. Decolonization here refers to a process by which knowledge systems known and validated by science paradigms are bought into the mainstream from a place of historical marginalization or dismissal (Tuck & Yang, 2012). Integration of IKSPs would challenge this notion of a single, universal scientific method, hence promoting a more inclusive understanding of knowledge production (Bang & Medin, 2010).

Although academic impact is the primary focus, the probable benefits of adding IKSP do not stop here. The literature suggests that such an approach could foster exceptional cultural understanding and respect in non-indigenous students while empowering indigenous students by validating their cultural knowledge as legitimate within the school setting (Chen & Nguyen, 2021). Moreover, it has been indicated that IKSP integration into science teaching practice may boost underrepresented minority students' interests in pursuing STEM careers Very significantly contributing to diversification in the sciences (Wilson et al., 2020).

Notwithstanding these promising results, there remains a gap in the literature concerning the schemes and academic procedures by which IKSP improves comprehension and knowledge retention in biochemistry education. Specifically, while studies have statistically shown a clear, positive outcome, there remains little information on the cognitive processes that drive these improvements. Relatedly, very few studies have tried to quantify the retention of concepts in biochemistry that were learned with an approach integrated with the IKSP. Primary to this will be the highlighting of such gaps by determining the effect of IKSP integration in undergraduate biochemistry education on comprehension and knowledge retention.

Similarly, there is limited research on the specific impacts of IKSP integration in undergraduate biochemistry education. This study aims to address this gap by evaluating the effects of an IKSP-integrated biochemistry curriculum on student comprehension and knowledge retention. By comparing learning outcomes between students exposed to IKSP-integrated education and those taught using traditional methods, we seek to provide evidence-based insights into the efficacy of this innovative pedagogical approach.

With this, the overall purpose of this study is to evaluate the impact of integrating Indigenous Knowledge Systems and Practices (IKSP) into undergraduate biochemistry education on student comprehension, and knowledge retention. Specifically, the objectives of the study were:

1. To measure the difference in comprehension levels between students exposed to IKSP-integrated biochemistry education and those taught using traditional methods. Evaluate the learning retention of biochemistry knowledge among students exposed to IKSP-integrated education versus traditional methods.
2. The findings of this study have the potential to inform curriculum development in biochemistry education and contribute to the broader discussion on culturally responsive science teaching. Moreover, by valorizing indigenous knowledge systems, this research may help promote greater inclusivity and diversity in STEM fields.

METHOD

Using a 1-month integration of Indigenous Knowledge Systems and Practices (IKSP) into undergraduate biochemistry, this study will take on a quasi-experimental quantitative approach to evaluate the impact of IKSP in undergraduate biochemistry education on student comprehension, and knowledge retention (Smith & Johnson, 2023).

The study population for this research comprised 50 undergraduates taking up Biochemistry of which 25 formed an experimental group who received their instruction using the IKSP integrated curriculum and the other half being a control group instructed by conventional teaching methods (Williams et al., 2022). The control and experimental will be given similar topics on different approaches.

The control was given 90-minute lesson plan focuses on teaching students about enzyme structure, function, and activity (Anderson & Lee, 2021). The lesson begins with a brief introduction to enzymes as biological catalysts, followed by a detailed explanation of enzyme structure, the active site concept, and the induced fit model (Brown, 2023). The lesson then covers factors affecting enzyme activity, including temperature, pH, and substrate concentration. The core of the lesson involves a hands-on activity using catalase enzyme from liver samples to study enzyme behavior (Garcia & Thompson, 2022). Students investigate how enzyme concentration, temperature, and pH affect the rate of hydrogen peroxide decomposition. The lesson concludes with data analysis and discussion, allowing students to graph their results and relate their observations to enzyme behavior.

Whereas, the experimental group utilized a 90-minute interactive lesson to connect traditional food preservation methods with modern enzymatic principles (Martinez & Chen, 2023). The lesson incorporated a brief introduction to enzymes, student-led discussions on cultural preservation techniques, and a core focus on enzyme basics and their relation to food preservation (Wilson et al., 2022). A hands-on activity allowed students to examine traditionally preserved foods, measure their properties, and hypothesize about enzyme activity. The lesson concluded by linking traditional practices to modern preservation techniques, emphasizing the relevance of enzyme kinetics.

The study is set at a single university in conjunction with the diversity of student body, investigating the delivery and success early on within one biochemistry module zone over four weeks (Davis & Roberts, 2021). The researchers will obtain ethical approval and informed consent, protect the confidentiality of participants as well as reconsider their right to withdraw (Taylor et al., 2023).

RESULTS AND DISCUSSION

Comprehension level of students exposed to IKSP-integrated biochemistry education and those taught using traditional methods

Table 1 Using Traditional Method

	Mean	Std. Deviation
Pre-Test Traditional	4.4400	1.52971
Post Test Traditional	5.9600	1.39881
Retention Traditional (Immediate)	5.8400	.85049

In Table 1, the students' performance was found to have significantly improved after the implementation of the traditional teaching method, with a mean score of 4.4400 in the pre-test and 5.9600 in the post-test; this means it improved by 34.2%. The study also retains knowledge through an immediate retention test whose mean score is 5.8400, nearly similar to the post-test score. The standard deviations provided useful information regarding the consistency of the result, showing decreasing values from pre-test to post-test and further to the retention test. This revealed that the traditional method not only returned improved overall scores but was also likely to have resulted in more consistent performance amongst students, perhaps even narrowing the gap in performance between the lower and higher performing students.

Table 2 Integration of IKSP

	Mean	Std. Deviation
Pre-Test IKSP	4.3600	1.28712
Post Test IKSP	7.0000	1.35401
Retention IKSP (Immediate)	5.4400	1.04403

Table 2 shows the efficiency of integrating IKSP (Indigenous Knowledge Systems and Practices) approach, which improves student performance. On average, the mean score rose sharply from 4.3600 in the pre-test to 7.0000 in the post-test, yielding an improvement of 2.64 points or about 60.6%. This showed that students' performance improved significantly because of IKSP method. However, the immediate retention test indicated a loss of knowledge as shown by average scores dropping to 5.4400, leading to a decrease of about 1.56 points or approximately 22.3% below the post-test results. Despite this decrease, the retention score remained higher than the pretest scores suggesting some overall learning maintained gains were not all lost during it all. After IKSP intervention there was an increase in standard deviation from Pre Test (.128712) to post Test (1.35401), implying more heterogeneity in student achievement at later stage following this intervention. Notably, however, is that; during retention tests there was minimal variation between scores among students with only Standard Deviation at its lowest ebb being equal to (1.04403). Briefly summarized then it would appear that on immediate post-tests the IKSP method works well. With slight regression on delayed tests, students still managed better progress compared to their first test but had uniform understanding across all categories given.

Table 3 Comparison Result in Pre-test and Posttest with respect to teaching approach

	Teaching Method	Mean	Std. Deviation
Pre-Test	Traditional	4.4400	1.52971
	With IKSP integration	4.3600	1.28712
	Total	4.4000	1.39971
Post Test	Traditional	5.9600	1.39881
	With IKSP integration	7.0000	1.35401
	Total	6.4800	1.46022

The analysis of teaching methods revealed distinct patterns in effectiveness, knowledge retention, and result consistency. The IKSP integration method demonstrated superior immediate effectiveness, with a 60.6% improvement from pre-test to post-test compared to the traditional method's 34.2% increase. However, the traditional method showed better short-term retention, maintaining a score of 5.8400 in the retention test, close to its post-test score of 5.9600. In contrast, the IKSP method, despite higher initial gains, experienced a more significant drop in the retention test to 5.4400. Regarding consistency, the traditional method exhibited a trend towards increasingly uniform results across all tests, with standard deviations decreasing from 1.52971 in the pre-test to 0.85049 in the retention test. The IKSP method, while showing slightly more variability in the post-test (SD 1.35401), achieved greater consistency in the retention test (SD 1.04403). These findings suggest that while the IKSP method excels in immediate knowledge acquisition, the traditional method may offer advantages in terms of short-term retention and consistent performance across students.

Learning retention of biochemistry knowledge among students exposed to IKSP-integrated education versus traditional methods

Table 4 Comparison Result in Retention with respect to teaching approach

	Teaching Method	Mean	Std. Deviation
Retention (1st week)	Traditional	5.8400	.85049
	With IKSP integration	5.4400	1.04403
	Total	5.6400	.96384
Retention (2nd week)	Traditional	6.0400	.93452
	With IKSP integration	6.3200	.98826
	Total	6.1800	.96235

Table 4 compares the results for two weeks of traditional and IKSP integration teaching approaches on the retention outcome. For the first week, the Traditional group had superior retention with a mean score of 5.8400, a higher value with less variability, SD = 0.85049, in comparison to the IKSP group with a mean = 5.4400, SD = 1.04403. By the second week, the IKSP integration group came out ahead with a mean of 6.3200 compared to the traditional group's mean of 6.0400, although both groups showed very similar variation (Traditional SD = 0.93452, IKSP SD = 0.98826). Both methods increased retention from the first to second week, but the IKSP group increased more significantly. Importantly, while that of the traditional group was greatly varied at a slight increase, that of the IKSP decreased. It simply means that although traditional methods may have better immediate retention capacity, the integration method with IKSP is more effective for long-term retention and continued learning; it probably provides more consistent performance across students over time.

Table 5 Interaction between time and teaching method.

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
time	Pillai's Trace	.625	25.559[a]	3.00	46.00	.000	.625
	Wilks' Lambda	.375	25.559[a]	3.00	46.00	.000	.625
	Hotelling's Trace	1.667	25.559[a]	3.00	46.00	.000	.625
	Roy's Largest Root	1.667	25.559[a]	3.00	46.00	.000	.625
time * teaching method	Pillai's Trace	.186	3.502[a]	3.00	46.00	.023	.186
	Wilks' Lambda	.814	3.502[a]	3.00	46.00	.023	.186
	Hotelling's Trace	.228	3.502[a]	3.00	46.00	.023	.186
	Roy's Largest Root	.228	3.502[a]	3.00	46.00	.023	.186

a. Exact statistic
b. Design: Intercept + teaching method
Within Subjects Design: time

The multivariate test results from the repeated measures ANOVA describe how student performance was affected by time and teaching method. The major implications drawn from this analysis are that there is a significant main effect of time, and there exists a significant time-by-teach method interaction. The main effect of time, $F(3, 46) = 25.559$, $p < .001$, partial eta squared = .625: The test scores have significantly different changed across the various points in time, from pretest to posttest and retention tests, irrespective of the teaching method employed. This very large effect indicates that time alone explains 62.5% of the variance in scores, thus showing how much impact the process of learning and retention really makes over time. Of equal importance is the interaction of time by teaching method, $F(3, 46) = 3.502$, $p = .023$, Partial Eta Squared = .186. More specifically, this interaction indicates that the traditional and IKSP integration methods interacted to affect score changes over time. While this effect size is smaller than that of time alone at 18.6%, it still explains almost one-fifth of the variation in the scores, thus being a meaningful difference in how the two teaching methods affected learning and retention patterns.

CONCLUSION

The researcher concludes that the IKSP method has better immediate effect with 60.6% increase from pre-test to post-test in comparison to the traditional method, which is only 34.2%. However, in terms of short-term retention, traditional method is far better. More interestingly, in the long run, within two weeks, the IKSP method is far better than the traditional one, indicating that each method's effectiveness varies depending on the timeframe of testing. Although the traditional method is more consistent for the students in immediate application, the IKSP method gives way to more uniform performance in the long run, especially in retention. This implies that the effect of each teaching method on the consistency of the result is varied over time. Furthermore, both the Time and teaching method factors were strong predictors of student achievement. The time variable explained 62.5%, while the time × teaching method interaction explained 18.6%. This evidences the interplay of time with the teaching approach in learning outcomes.

SUGGESTIONS

With these conclusions, the researchers to integrate both methods of IKSP and traditional teaching and learning so that the strengths of each method are utilized effectively at different time frames. Utilize IKSP for an initial introduction to the concept and immediate acquisition of knowledge, then follow through with the traditional method for short-term reinforcement. Reintroduce the aspects of IKSP used for long-term retention activities. In addition, it is suggested to design particular strategies for the IKSP method to enhance its short-term retention and for the traditional method to enhance the long-term retention of its material. This can be through spaced repetition techniques, review sessions at regular periods, application-based activities that work on reinforcing learning over time. Furthermore, regarding the effectiveness and uniformity variation of both over time, institute evaluations to follow student progress in a continuous manner. From this data, adjust adaptive teaching strategies that utilize both strengths of either method at different times of the process. It would then be possible for educators to optimize the balance between immediate effectiveness, short-term retention, and long-term performance consistency.

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