Interdisciplinary Brain-based Learning Strategies in Addressing Liver Fluke Disease and Cultural Dietary Practices among Early Childhood Students

Angkana Tungkasamit[1], Nattapon Meekaew[1,*], Somkamon Boonmee[1], Prapaporn Jantaburom[1] & Ladda Silanoi[1]

[1]Faculty of Education, Khon Kaen University, Khon Kaen, Thailand

*Correspondence: Faculty of Education, Khon Kaen University, Khon Kaen, Thailand. Tel: 66-84-029-5689. E-mail: nattame@kku.ac.th

Received: June 27, 2024 Accepted: October 3, 2024 Online Published: October 18, 2024

doi:10.5430/jct.v13n5p81 URL: https://doi.org/10.5430/jct.v13n5p81

Abstract

Liver fluke disease remains a critical public health issue in Southeast Asia, driven by cultural dietary practices involving raw or undercooked freshwater fish. This study evaluates the impact of an interdisciplinary brain-based learning intervention aimed at increasing awareness and modifying dietary behaviors among early childhood students in Central Northeast Thailand. A quasi-experimental design was employed, involving 122 students from four provinces. The intervention incorporated brain-based learning activities such as storytelling, songs, and visual aids to enhance engagement. Pre- and post-tests, behavioral observations, and attitudinal surveys were conducted to assess the program's effectiveness. Post-intervention results indicated significant improvements in knowledge about liver fluke transmission, symptoms, and prevention, alongside positive changes in behavior, such as increased avoidance of raw fish consumption and improved hygiene practices. Attitudinal surveys showed a shift in preferences toward safer eating habits. These findings suggest integrating brain-based learning with culturally relevant health education can foster sustainable behavior change in early childhood populations. Further research is recommended to explore this approach's long-term impacts and scalability.

Keywords: liver fluke disease, brain-based learning, health education, cultural practices, early childhood

1. Introduction

1.1 Introduce the Problem

Liver fluke infection caused by *Opisthorchis viverrini* is a major public health issue in Southeast Asia, particularly in regions where the consumption of raw or undercooked freshwater fish is a cultural norm (Pumhirunroj et al., 2020; Sripa et al., 2011; Sithithaworn et al., 2012). This parasitic infection, deeply embedded in local dietary customs, often leads to severe health consequences, including cholangiocarcinoma, a lethal form of bile duct cancer (Khuntikeo et al., 2016; Sripa et al., 2011). Despite numerous public health interventions, the persistence of liver fluke infections highlights the difficulty in changing deeply rooted cultural practices contributing to disease transmission (Kaewpitoon et al., 2008; Jongsuksuntigul & Imsomboon, 2003).

These dietary behaviors are prevalent among populations in rural Thailand, where public health efforts face the challenge of increasing knowledge and altering long-standing cultural habits (Tungkasamit et al., 2024; Resnicow et al., 1999). The educational system, particularly at the early childhood level, provides a unique opportunity to address these public health concerns by embedding health education into early learning environments. The challenge lies in making such educational interventions engaging and effective in altering behaviors, particularly in young children influenced by their families' cultural practices.

1.2 Explore Importance of the Problem

The significance of liver fluke disease prevention cannot be overstated, given its link to cholangiocarcinoma, a cancer with a high mortality rate (Sripa et al., 2017; Khuntikeo et al., 2016). Addressing this public health issue through education, particularly in early childhood, holds potential for long-term behavioral change. Early childhood is a critical developmental stage for shaping health behaviors that can last a lifetime (Ansari et al., 2011; Leech et al.,

2015). Interventions that focus on young learners are essential for educating children and influencing the broader community, as children often become conduits for health-related information within their households (Immordino-Yang et al., 2019).

Given the limitations of traditional public health campaigns in this context, an innovative approach is required—one that integrates culturally responsive education with neuroscience-based learning strategies to engage young students better and foster meaningful behavior change (Betancourt et al., 2003; Kagawa Singer et al., 2015). This study seeks to fill this gap by exploring how brain-based learning strategies can be leveraged to educate early childhood students about liver fluke disease with the aim of influencing both their knowledge and behaviors related to dietary practices.

1.3 Describe Relevant Scholarship

1.3.1 Liver Fluke Disease and Cultural Practices

The relationship between cultural dietary practices and the prevalence of liver fluke infections has been extensively studied in Southeast Asia. Communities in this region, particularly in Thailand, maintain traditions of consuming raw or undercooked freshwater fish, a key factor in the transmission of *Opisthorchis viverrini* (Kaewpitoon et al., 2008; Jongsuksuntigul & Imsomboon, 2003). These practices are deeply embedded in rural communities' social and cultural fabric, making them resistant to change despite public health warnings (Sripa et al., 2011; Pumhirunroj et al., 2020).

The severe health outcomes of liver fluke infections, particularly cholangiocarcinoma, underscore the need for more innovative approaches that consider both the biological and cultural dimensions of the disease (Khuntikeo et al., 2016; Sithithaworn et al., 2012). Without culturally sensitive interventions, public health strategies risk being ineffective, as they may not resonate with local populations who perceive these dietary practices as an integral part of their identity (Kagawa Singer et al., 2015; Resnicow et al., 1999).

1.3.2 Early Childhood Education and Health Promotion

Early childhood represents a critical period for the development of lifelong health behaviors. Research shows that health education delivered during these formative years can significantly shape children's attitudes, knowledge, and behaviors, laying the foundation for healthier lifestyles (Ansari et al., 2011; Bartelink et al., 2019; Goldfeld et al., 2018). However, traditional health education methods often fall short in engaging young learners, particularly in contexts where cultural practices are at odds with the desired health behaviors (Sripa et al., 2017; Schirmer & Lockman, 2022).

Interactive and developmentally appropriate methods, such as storytelling, play, and multisensory activities, are more effective in teaching health concepts to young children (Thomas et al., 2019). By fostering engagement and making learning enjoyable, these methods promote better retention of health information and encourage behavior change. This aligns with the principles of early childhood education, which emphasize experiential learning and the importance of creating nurturing environments that support children's cognitive, social, and emotional development (Napier et al., 2017; Sousa, 2016; Betancourt et al., 2003).

1.3.3 Brain-Based Learning and Educational Neuroscience

Brain-based learning, grounded in educational neuroscience, offers a promising framework for enhancing the effectiveness of health education, particularly for young children. This approach aligns teaching methods with the brain's natural learning processes, making education more engaging and effective (Tokuhama-Espinosa, 2011; Dubinsky et al., 2013; Leisman, 2022). Key principles of brain-based learning include creating emotionally supportive learning environments, employing multisensory experiences, and fostering active learning through hands-on activities and social interaction (Sousa, 2016).

These strategies can be particularly impactful for early childhood learners, whose brains are highly receptive to multisensory inputs (Ansari et al., 2011; Immordino-Yang et al., 2019). By incorporating activities such as interactive storytelling, songs, and visual aids, brain-based learning taps into young children's natural curiosity and enthusiasm, making health education enjoyable and memorable (Chang et al., 2021).

1.3.4 Integrating Cultural Sensitivity with Brain-Based Health Education

A growing body of literature emphasizes the importance of cultural sensitivity in health education, particularly when addressing health issues tied to long-standing cultural practices (Kagawa Singer et al., 2015; Napier et al., 2017). For interventions to be effective, they must resonate with the target population by acknowledging and respecting cultural norms while promoting safer practices. Studies have shown that integrating culturally relevant content into health education can lead to more significant and sustained behavior change (Resnicow et al., 1999; Kreuter & McClure,

2004).

When combined with brain-based learning, culturally sensitive health education becomes even more powerful. This integration allows educators to deliver health messages in ways that are not only cognitively engaging but also culturally relevant and meaningful to learners (Tokuhama-Espinosa, 2011). For example, incorporating local stories or traditions into the educational content can enhance its resonance and acceptance, increasing the likelihood that the target behaviors will be adopted (Betancourt et al., 2003).

In summary, integrating brain-based learning with culturally sensitive health education provides a holistic approach to tackling complex health issues like liver fluke disease. By addressing both the cognitive and cultural dimensions of learning, this approach can potentially promote sustainable behavior change, especially in early childhood populations.

1.4 State Hypotheses and Their Correspondence to Research Design

The primary hypothesis of this study is that a brain-based, culturally relevant educational intervention will significantly improve knowledge about liver fluke disease and result in positive changes in dietary behaviors among early childhood students in Central Northeast Thailand. Specifically, it is hypothesized that students exposed to this intervention will demonstrate:

1. Increased knowledge about liver fluke transmission, symptoms, and prevention.
2. Behavioral changes, particularly reduced raw or undercooked fish consumption.
3. Attitudinal shifts toward the adoption of safer eating practices.

These hypotheses are grounded in the principles of brain-based learning, which suggest that multisensory and emotionally engaging educational experiences are more likely to result in retained knowledge and behavioral change. The quasi-experimental research design, involving pre- and post-tests, behavioral observations, and attitudinal surveys, will assess the intervention's impact on these key outcomes.

2. Method

2.1 Research Design

This study employs a quasi-experimental design, specifically a non-equivalent control group design with pre-test and post-test measures. This design was selected to evaluate the effectiveness of a brain-based educational intervention aimed at altering knowledge and cultural dietary practices concerning liver fluke disease in early childhood populations of Central Northeast Thailand.

2.2 Participants and Settings

The study focuses on early childhood students aged 4 to 6 from four provinces in Central Northeast Thailand, including Khon Kaen, Roi Et, Kalasin, and Maha Sarakham. These provinces were chosen due to their varying prevalence rates of liver fluke disease, a significant health concern linked to local dietary customs, particularly the consumption of raw or undercooked freshwater fish.

One school from each province was selected, with all students from a single early childhood classroom included in the study. The distribution of participants across the provinces includes 36 from Khon Kaen, 29 from Roi Et, 32 from Kalasin, and 28 from Maha Sarakham. These schools are located in rural communities, where traditional lifestyles and dietary habits prevail, providing a rich context for implementing and observing the impact of a brain-based educational curriculum.

2.3 Sampling procedure

Purposive sampling was employed to select the schools, ensuring they were situated in areas with significant variability in the prevalence of liver fluke disease. This method allowed for selecting locations representative of different environmental and cultural conditions influencing disease transmission, ensuring a comprehensive examination of the intervention across diverse settings.

The study involved entire classrooms of early childhood students to ensure complete immersion of the educational intervention within the existing educational framework. This non-probabilistic approach maximizes the intervention's exposure and provides a holistic view of its impact without the confounding variables that might arise from partial classroom participation.

Class selection criteria included the students' age group (4 to 6 years old), their regular enrolment in the early

childhood program, and the feasibility of implementing the intervention within the school's existing infrastructure. This methodology enhances the external validity of the study results, ensuring that the research findings will be relevant and applicable to similar educational and cultural contexts.

2.4 Intervention

The innovative curriculum was developed by a multidisciplinary team comprising experts in education, neuroscience, public health, and cultural studies. It was designed to educate early childhood students about liver fluke disease and cholangiocarcinoma, strongly emphasizing prevention and community health. The curriculum incorporated brain-based learning strategies to ensure the content was engaging and memorable for young learners. It covered crucial topics such as the nature and transmission of liver flukes, the relationship between dietary habits and disease prevention, and the importance of hygiene and sanitation.

It employed multisensory learning techniques to support diverse learning styles, including animations, physical activities, and interactive storytelling, facilitating active and experiential learning. Emotional engagement was fostered through narratives that connected students emotionally with the material, enhancing empathy and understanding. Collaborative activities encouraged peer interaction, critical for developing social skills and reinforcing communal responsibility toward disease prevention. Repetition and reinforcement were strategically used to ensure retention and understanding, with continuous feedback and reflection exercises embedded to help students consolidate their knowledge and apply it in real-world contexts. The curriculum also included supplementary materials, such as storybooks, audiovisual resources, and interactive digital media, to support brain-based learning experiences.

Additionally, trained early childhood educators from the intervention school underwent a comprehensive professional development program to understand the principles of brain-based learning, the curriculum content, and the recommended instructional strategies. This training ensured fidelity in implementing the intervention as intended. The intervention was implemented for eight weeks during regular school hours. Regular monitoring and support were provided to the educators to address any challenges and ensure consistent implementation.

Fidelity measures, such as classroom observations, lesson plan reviews, and educator feedback, were incorporated to assess the extent to which the intervention was delivered as designed and to identify any deviations or adaptations made during implementation.

2.5 Measurements

A bespoke knowledge test is employed to assess the educational impact of the intervention on students' understanding of liver fluke disease. This pictorial multiple-choice questionnaire evaluates the children's comprehension of the liver fluke's lifecycle, transmission methods, symptoms, and preventive measures. Administered before and after the intervention, these tests are designed to measure the initial knowledge levels and information retention post-intervention. The scoring of these tests quantitatively evaluates the improvement in knowledge, providing a direct measure of the cognitive impact of educational activities.

Behavioral observations form the second component of the study's measurements, focusing on students' engagement in safe dietary practices. Observers, trained to use a structured protocol, note behaviors related to food handling during school activities, such as lunchtime or specific health classes. These observations aim to record changes in the children's behavior, especially their selection and preparation of fish and their interactions with food safety. By comparing pre- and post-intervention behaviors, the study quantifies changes in safe practices, thus measuring the practical application of learned content.

Lastly, attitudinal surveys gauge shifts in students' perceptions and attitudes toward consuming cooked versus raw fish. These surveys feature visually engaging scales suitable for young children and are administered alongside the knowledge tests. Analyzing these surveys helps understand the attitudinal shifts that accompany the knowledge gains, providing insight into how changes in understanding may influence students' dietary choices and behaviors. This comprehensive approach ensures a multi-dimensional assessment of the intervention's efficacy, capturing cognitive, behavioral, and attitudinal outcomes.

2.6 Data Collection

Data collection for this study is meticulously planned to capture a comprehensive set of data points across cognitive, behavioral, and attitudinal dimensions. Pre-intervention data are collected one week before the educational program begins to establish baseline measures for each participant. This baseline includes administering the knowledge tests and attitudinal surveys and initiating the behavioral observations. These initial assessments provide critical data

against which post-intervention outcomes can be compared, ensuring that any changes observed can be accurately attributed to the intervention.

During the intervention, trained observers continuously collected behavioral data using standardized forms. These observers record specific predefined behaviors during selected school activities, particularly those involving food handling and discussions about dietary practices. This real-time data collection is crucial for assessing the immediate effects of the intervention on students' behaviors and allows for adjustments in observation strategies if needed. In addition to behavioral observations, educators complete logs detailing their observations and any notable student interactions or reactions related to the educational content.

Post-intervention data collection occurs immediately after the intervention concludes, with follow-up assessments potentially scheduled three months later to evaluate the persistence of the intervention's effects. The post-intervention phase involves re-administering the knowledge tests and attitudinal surveys to all participants, along with a final set of behavioral observations. This approach ensures that data on the long-term impact of the intervention, particularly in terms of sustained knowledge retention and behavioral changes, are accurately captured.

2.7 Data Analysis

Quantitative data from knowledge tests and behavioral observations are analyzed to determine the statistical significance of changes observed throughout the study. Using paired t-tests or Wilcoxon signed-rank tests, changes in knowledge test scores from pre- to post-intervention are evaluated depending on the normality of the data distribution. This analysis helps quantify the educational intervention's cognitive impact, providing clear metrics on learning outcomes and information retention.

Qualitative data from attitudinal surveys and observational notes are subjected to thematic analysis to identify prevalent themes and patterns. This analysis involves coding the data to highlight common responses and behaviors that signify shifts in students' attitudes and practices related to liver fluke disease prevention. Integrating these qualitative insights with quantitative results paints a comprehensive picture of how educational interventions influence conscious attitudes and unconscious behaviors.

Integrating quantitative and qualitative data through a mixed-methods approach allows for a robust analysis of the intervention's effectiveness. Statistical analyses are conducted using advanced software tools like SPSS or R, which facilitate detailed data manipulation and enable precise conclusions. This mixed-methods analysis validates the educational content's effectiveness and enhances understanding of how education affects behavioral and attitudinal change in young students.

2.8 Ethic Consideration

This study received approval from the Institutional Review Board (IRB) at Khon Kaen University. Informed consent was obtained from parents and guardians, and detailed information was provided about the study. Participant confidentiality and anonymity were ensured, with data reported in aggregate form. The educational content was age-appropriate and culturally sensitive to minimize risks. Researchers were trained to interact ethically with children, providing a supportive environment. An independent monitoring committee oversaw the study to ensure compliance with ethical standards and address any issues promptly, protecting the welfare of all participants.

3. Results

3.1 Demographics

This study included 122 early childhood students from four provinces in Central Northeast Thailand, which are known for varying prevalence rates of liver fluke disease. The distribution of participants was as follows: Khon Kaen (36 participants), Roi Et (29 participants), Kalasin (32 participants), and Maha Sarakham (28 participants). The ages of participants ranged from 4 to 6 years, with an equal distribution of boys and girls across the schools.

Table 1 highlights the equal distribution of male and female participants across the four provinces. The average age range of 4 to 6 years represents an early childhood demographic, a critical developmental stage for influencing long-term health behaviors. The socio-economic backgrounds of the participants, mainly from agricultural communities, underscore the relevance of the liver fluke intervention. These children, raised in environments where traditional dietary habits involving raw or undercooked fish are prevalent, are an ideal target group for educational initiatives to change health-related behaviors.

Table 1. Demographic Characteristics of Participants by Province

Province	Number of participants	Gender distribution	
		Male	Female
Khon Kaen	36	14	22
Roi Et	29	12	17
Kalasin	32	15	17
Maha Sarakham	28	14	14

3.2 Knowledge Test Outcomes

The knowledge tests administered before and after the educational intervention significantly improved students' understanding of liver fluke disease. Pre-test results indicated that most students had limited knowledge of the disease's transmission, symptoms, and prevention. However, post-test results revealed substantial gains in knowledge across all key topics, with notable increases in understanding of transmission methods, symptoms of infection, and preventive measures. These findings suggest that the brain-based learning strategies used in the intervention were highly influential in facilitating the acquisition and retention of health-related information.

Table 2. Comparison of Pre- and Post-Test Knowledge Scores

Topic	Pre-Test Correct (%)	Post-Test Correct (%)	p-value
Lifecycle of Liver Fluke	45	78	<0.01
Transmission Methods	50	85	<0.01
Symptoms of Infection	55	82	<0.01
Preventive Measures	90	90	<0.01

Table 2 clearly illustrates the statistically significant improvements in correct responses across all categories of liver fluke disease knowledge. For instance, knowledge of preventive measures improved dramatically, with correct responses rising from 40% to 90%. Similarly, students' understanding of the liver fluke lifecycle increased from 45% to 78%, and their knowledge of transmission methods improved from 50% to 85%. The statistical significance ($p < 0.01$ for all topics) confirms that the intervention had a meaningful impact on the student's comprehension of these critical health topics. These findings suggest that the intervention was highly influential in enhancing students' awareness and understanding of liver fluke disease, which is critical for prevention efforts in their communities. Additionally, this highlights the extent of improvement, demonstrating how educational interventions can effectively enhance knowledge in critical health areas among early childhood students. Using vivid, relatable materials as part of the brain-based teaching approach played a significant role in these outcomes.

3.3 Behavioral Observations

Behavioral observations during the study revealed significant changes in students' practices that are critical for preventing liver fluke disease. Observers carefully recorded students adopting safer behaviors during mealtimes and classroom discussions, indicating a noticeable shift towards healthier practices following the educational intervention. These behavioral changes are particularly important because they reflect not only an increase in knowledge but also the application of that knowledge in daily routines, reinforcing the potential for long-term behavioral shifts.

Table 3. Summary of Observed Behavioral Changes

Behavior Description	Pre-Test Correct (%)	Post-Test Correct (%)	p-value
Avoiding raw fish	30	70	<0.01
Proper washing of hands	40	85	<0.01
Engaging in discussions about safe eating	20	65	<0.01

Table 3 illustrates the statistically significant improvements in student behaviors across all key prevention strategies. The percentage of students avoiding raw fish increased from 30% to 70% ($p < 0.01$), highlighting a meaningful reduction in risky dietary habits. Proper handwashing practices, another critical prevention behavior, substantially increased from 40% to 85% ($p < 0.01$), demonstrating improved hygiene awareness. Additionally, the engagement in

discussions about safe eating practices rose from 20% to 65% ($p < 0.01$), indicating that students were not only internalizing the health messages but also actively sharing them with their peers.

The qualitative observations enriched these findings, capturing the nuanced ways students internalized and expressed their new knowledge. For instance, one observer noted,

"During lunch, I heard several students cautioning their peers, saying, 'Do not eat that; it has not been cooked well. Remember what we learned about the worms!' This shows a direct application of their learning"

This quote demonstrates the intervention's immediate impact on students' behavior. The peer-to-peer cautioning about undercooked food shows the active application of learned concepts and internalization of key health messages. Students link undercooked food with worm infection, clearly understanding disease transmission. The casual lunch setting suggests that this knowledge has become part of their daily discourse, potentially reinforcing new behaviors through peer influence. This observation highlights how the brain-based learning approach has successfully connected educational content to real-life situations, fostering a sense of responsibility for their and their peers' health. Another observer reported,

"A student, previously observed eating undercooked dishes, proudly showed her friends how she now always makes sure her fish is well-cooked. She said, 'My mom and I cook it together now. I told her what we learned about the liver fluke."

This quote illustrates the intervention's broader impact. The student's shift from eating undercooked dishes to ensuring proper cooking demonstrates direct behavior change. Her pride in sharing this new practice suggests a positive emotional association crucial for long-term adherence. The quote also reveals the intervention's reach beyond the school, with the student influencing her household's behaviors. This intergenerational transfer of knowledge indicates effective retention and communication of health concepts. The collaborative cooking with her mother shows the intervention's sensitivity to cultural practices, promoting safer alternatives without rejecting traditional foods. These qualitative insights illustrate a change in behaviors and an evolving community dialogue around health practices, showcasing the profound impact of the brain-based educational approach on modifying culturally ingrained dietary habits. These observations are powerful testimonials of the program's effectiveness and the potential for educational interventions to catalyze community-wide health improvements.

3.4 Attitudinal Survey Results

The attitudinal surveys conducted before and after the intervention revealed meaningful shifts in students' perceptions of safe eating practices, particularly concerning the consumption of cooked versus raw fish. These shifts are critical for assessing the potential for long-term behavioral change in the context of liver fluke disease prevention. The surveys focused on key attitudinal metrics such as preference for cooked fish, understanding the importance of cooking fish to prevent disease, and willingness to discuss safe eating practices.

Table 4. Attitudinal Changes Towards Fish Consumption

Survey Item	Pre-Test Correct (%)	Post-Test Correct (%)	p-value
Preference for cooked over raw fish	40	80	<0.01
Understanding of cooking fish to prevent disease	35	75	<0.01
Willingness to discuss safe eating practices	30	70	<0.01
Preference for cooked over raw fish	40	80	<0.01

Table 4 shows a substantial and statistically significant improvement in all measured attitudinal items. The preference for cooked fish over raw fish increased from 40% to 80% ($p < 0.01$), reflecting a critical shift away from risky dietary behaviors that contribute to liver fluke infection. Similarly, understanding the importance of cooking fish as a preventive measure increased from 35% to 75% ($p < 0.01$). This suggests that students better understand the health risks of consuming raw or undercooked fish. Additionally, the willingness to discuss safe eating practices rose from 30% to 70% ($p < 0.01$), indicating that students were not only adopting these behaviors but also actively promoting them among their peers.

These surveys reveal that not only did the students absorb the information presented, but they also internalized it enough to change their attitudes significantly. For instance, the shift in preference for cooked over raw fish is particularly notable given the local cultural norms. One student commented in the post-survey,

"I now like the cooked fish better because I know it keeps me safe from the sickness"

This quote reveals a significant attitudinal shift resulting from the intervention. The student's preference for cooked fish is now based on health knowledge, showing internalization of disease prevention concepts. This change is particularly noteworthy given the cultural context where raw fish consumption is traditional, suggesting the intervention has successfully influenced deeply ingrained dietary preferences. Furthermore, the increased willingness to discuss safe eating practices among peers suggests an enhanced communal awareness, essential for public health interventions to have a lasting impact. An observer noted,

"Students are now more vocal during meals, reminding each other about what they learned about safe eating."

This observation demonstrates the development of collective health consciousness among students. The increased discussion about safe eating practices during meals indicates that food safety has become a regular topic of conversation. This peer-to-peer reinforcement is crucial for sustaining behavior change by creating a supportive social environment. Integrating these discussions into mealtimes shows that health knowledge has been successfully contextualized into daily life, bridging the gap between abstract information and practical application. These observed behavior changes align with the quantitative data showing an increased willingness to discuss safe eating practices. These qualitative findings, supported by the quantitative data, demonstrate how educational intervention successfully influenced knowledge and attitudes, potentially leading to healthier community practices.

3.5 Correlation Analysis of Knowledge, Behavior, and Attitudes

The correlation analysis provides a comprehensive view of the intervention's overall effectiveness by examining the relationships between changes in students' knowledge, behaviors, and attitudes. This holistic approach highlights the interconnected nature of these elements, demonstrating how gains in knowledge directly influence both behavioral changes and shifts in attitudes.

Table 5. Correlation between Knowledge Gain, Behavioral Change, and Attitudinal Shifts

Outcome Measure	Knowledge Gain Correlation	Behavior Change Correlation	Attitude Shift Correlation
Avoiding raw fish	0.65	-	0.60
Hand washing practices	0.70	0.72	-
Discussions about safe eating	0.55	0.68	0.71

Table 5 shows strong positive correlations between the knowledge gained through the intervention and the corresponding behavioral and attitudinal changes. The correlation between knowledge about the dangers of raw fish consumption and the behavior of avoiding raw fish was substantial ($r = 0.65$), indicating that an increased understanding of the risks led to a significant change in dietary practices. Likewise, the attitudinal shift toward preferring cooked fish also strongly correlated with knowledge gains ($r = 0.60$), further confirming that knowledge is a critical driver of attitudinal change.

4. Discussion

This study investigated the effectiveness of a brain-based educational intervention designed to increase knowledge about liver fluke disease and promote behavior change regarding raw or undercooked fish consumption among early childhood students in Northeast Thailand. The findings provide valuable insights into how culturally responsive health education strategies can significantly impact knowledge, attitudes, and behaviors, particularly in regions where public health challenges are closely tied to cultural practices.

The results demonstrated substantial improvements in students' understanding of liver fluke disease transmission, symptoms, and prevention methods following the intervention. These findings align with previous research, reinforcing the effectiveness of brain-based learning approaches in enhancing knowledge acquisition and retention (Chang et al., 2021; Sousa, 2016). By incorporating multisensory experiences, storytelling, and interactive activities, the intervention successfully engaged young learners, delivering health information in an engaging and memorable way.

Beyond the increase in knowledge, the study revealed notable shifts in students' attitudes and behaviors related to disease prevention. Students strongly preferred consuming cooked fish over raw fish and showed an increased willingness to discuss safe eating practices with their peers. These changes suggest that the intervention not only provided information but also helped students internalize and apply the content in real-life contexts, a hallmark of

effective brain-based learning (Tokuhama-Espinosa, 2011; Thomas et al., 2019). This highlights the power of educational interventions that connect classroom learning with everyday practices, fostering active engagement and promoting long-term behavior change.

The integrated analysis further revealed strong correlations between knowledge acquisition, behavioral changes, and attitudinal shifts. As students' understanding of liver fluke disease deepened, their behaviors and attitudes evolved accordingly, demonstrating a more significant commitment to disease prevention. This interconnectedness underscores the potential for brain-based interventions to initiate a ripple effect, where education impacts not only individual students but also influences broader community dialogues and practices. This is particularly relevant in public health, where changing cultural behaviors can be challenging but essential for disease prevention.

The findings contribute to the growing body of evidence supporting the integration of brain-based learning principles into health education, particularly in cultural contexts where deeply ingrained practices pose significant public health risks. This intervention effectively addressed a public health issue rooted in traditional dietary customs by aligning instructional strategies with the brain's natural learning processes and incorporating culturally relevant elements. The success of this approach suggests that brain-based learning when paired with culturally tailored content, can be a powerful tool for promoting positive health behaviors.

The study's unique contribution lies in its focus on early childhood education and integrating brain-based learning with culturally sensitive content. While previous research has highlighted the importance of addressing liver fluke disease through community-based or EcoHealth approaches (Sripa et al., 2017; Tungkasamit et al., 2024), this study demonstrates the added value of incorporating neuroscience-based strategies into educational interventions aimed at young learners. By leveraging insights from neuroscience and culturally responsive teaching methods, the intervention facilitated not only the acquisition of health knowledge but also its practical application, leading to sustained behavior change.

Moreover, the study highlights the importance of cultural factors in health education. As Kagawa Singer et al. (2015) emphasize, culturally responsive approaches are crucial for ensuring the acceptance and effectiveness of health interventions. This intervention resonated with the target population by respecting and integrating elements of local traditions and involving community stakeholders, increasing its potential for long-term impact. These findings suggest that similar culturally tailored, brain-based interventions could be implemented in other regions facing similar public health challenges.

Despite the promising results, several limitations must be acknowledged. The study's focus on a specific geographic region and age group may limit the generalizability of its findings to other cultural contexts or educational settings. Additionally, the study's relatively short duration may not fully capture the long-term sustainability of the observed behavior changes. Future research should explore the longevity of these impacts and investigate the potential for scaling up brain-based interventions across broader populations and diverse health education contexts. Expanding the scope of such interventions could provide further evidence of their effectiveness in addressing culturally ingrained health challenges.

In conclusion, this study provides compelling evidence for the effectiveness of brain-based educational interventions in promoting knowledge, attitude, and behavior changes related to culturally situated health issues such as liver fluke disease among early childhood students. Integrating neuroscience principles, multisensory learning experiences, and cultural relevance proved a powerful approach to tackling complex public health challenges rooted in traditional practices. The findings support the growing call for interdisciplinary, culturally responsive strategies in health education, particularly in early childhood settings, and suggest that such interventions could be scaled to address similar health issues in other contexts. Future research should aim to explore the scalability and sustainability of these interventions to ensure their long-term effectiveness in promoting positive health behaviors.

References

Alvidrez, J., Nápoles, A. M., Bernal, G., Lloyd, J., Cargill, V., Godette, D., et al. (2019). Building the evidence base to inform planned intervention adaptations by practitioners serving health disparity populations. *American Journal of Public Health, 109*(S1). https://doi.org/10.2105/AJPH.2018.304915

Ansari, D., Coch, D., & De Smedt, B. (2011). Connecting education and cognitive neuroscience: Where will the journey take us? *Educational Philosophy and Theory, 43*(1), 37-42. https://doi.org/10.1111/j.1469-5812.2010.00705.x

Ansari, D., König, J., Leask, M., & Tokuhama-Espinosa, T. (2017). Developmental cognitive neuroscience:

Implications for teachers' pedagogical knowledge. In S. Guerriero (Ed.), *Pedagogical knowledge and the changing nature of the teaching profession* (pp. 195-222). OECD Publishing. https://doi.org/10.1787/9789264270695-11-en

Bartelink, N., van Assema, P., Jansen, M., Savelberg, H., Moore, G., Hawkins, J., et al. (2019). Process evaluation of the healthy primary school of the future: The key learning points. *BMC Public Health, 19*(1), 698. https://doi.org/10.1186/s12889-019-6947-2

Betancourt, J. R., Green, A. R., Carrillo, J. E., & Ananeh-Firempong, O., II. (2003). Defining cultural competence: A practical framework for addressing racial/ethnic disparities in health and health care. *Public Health Reports, 118*(4), 293-302. https://doi.org/10.1093/phr/118.4.293

Chang, Z., Schwartz, M. S., Hinesley, V., & Dubinsky, J. M. (2021). Neuroscience concepts changed teachers' views of pedagogy and students. *Frontiers in Psychology, 12*, 685856. https://doi.org/10.3389/fpsyg.2021.685856

Dubinsky, J. M., Roehrig, G., & Varma, S. (2013). Infusing neuroscience into teacher professional development. *Educational Researcher, 42*(6), 317-329. https://doi.org/10.3102/0013189X13499403

Goldfeld, S., O'Connor, M., O'Connor, E., Chong, S., Badland, H., Woolfenden, S., et al. (2018). More than a snapshot in time: Pathways of disadvantage over childhood. *International Journal of Epidemiology, 47*(4), 1307-1316. https://doi.org/10.1093/ije/dyy086

Gustafsson, J., Ray, C., Lehto, E., Roos, E., & Lehto, R. (2023). Role of early childhood educators' demographic characteristics and perceived work environment in implementation of a preschool health promotion intervention. *Archives of Public Health, 81*(1), 54. https://doi.org/10.1186/s13690-023-01133-z

Immordino-Yang, M. H., Darling-Hammond, L., & Krone, C. R. (2019). *The brain basis for integrated social, emotional, and academic development: How emotions and social relationships drive learning*. The Aspen Institute.

Jongsuksuntigul, P., & Imsomboon, T. (2003). Opisthorchiasis control in Thailand. *Acta Tropica, 88*(3), 229-232. https://doi.org/10.1016/j.actatropica.2003.01.002

Kaewpitoon, N., Kaewpitoon, S. J., & Pengsaa, P. (2008). Opisthorchiasis in Thailand: Review and current status. *World Journal of Gastroenterology, 14*(15), 2297-2302. https://doi.org/10.3748/wjg.14.2297

Kagawa Singer, M., Dressler, W., George, S., & Elwood, W. (2015). *The cultural framework for health: An integrative approach for research and program design and evaluation*. National Institutes of Health, Office of Behavioral and Social Sciences Research.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(1), 11. https://doi.org/10.1186/s40594-016-0046-z

Khuntikeo, N., Loilome, W., Thinkhamrop, B., Chamadol, N., & Yongvanit, P. (2016). A comprehensive public health conceptual framework and strategy to effectively combat cholangiocarcinoma in Thailand. *PLoS Neglected Tropical Diseases, 10*(1). https://doi.org/10.1371/journal.pntd.0004293

Kreuter, M. W., & McClure, S. M. (2004). The role of culture in health communication. *Annual Review of Public Health, 25*, 439-455. https://doi.org/10.1146/annurev.publhealth.25.101802.123000

Langford, R., Bonell, C., Komro, K., Makleff, S., Dyson, A., Marshall, L., et al. (2017). The Health Promoting Schools Framework: Known unknowns and an agenda for future research. *Health Education & Behavior, 44*(3), 463-475. https://doi.org/10.1177/1090198116673800

Leech, R. M., McNaughton, S. A., & Timperio, A. (2015). Clustering of diet, physical activity and sedentary behaviour among Australian children: Cross-sectional and longitudinal associations with overweight and obesity. *International Journal of Obesity, 39*(7), 1079-1085. https://doi.org/10.1038/ijo.2015.66

Leisman, G. (2022). Neuroscience in education: A bridge too far or one that has yet to be built: Introduction to the "Brain Goes to School." *Brain Sciences, 13*(1), 40. https://doi.org/10.3390/brainsci13010040

Napier, A. D., Depledge, M., Knipper, M., Lovell, R., Ponarin, E., Sanabria, E., & Thomas, F. (2017). *Culture matters: Using a cultural contexts of health approach to enhance policy-making*. World Health Organization, Regional Office for Europe. https://iris.who.int/handle/10665/344101

Pumhirunroj, B., Aukkanimart, R., Boonmars, T., Sriraj, P., Boueroy, P., & Artchayasawat, A. (2020). Liver fluke-infected cyprinoid fish in northeastern Thailand (2016-2017). *Southeast Asian Journal of Tropical*

Medicine and Public Health, 51(1), 1-7. https://doi.org/10.5555/20210153069

Resnicow, K., Baranowski, T., Ahluwalia, J. S., & Braithwaite, R. L. (1999). Cultural sensitivity in public health: Defined and demystified. *Ethnicity & Disease, 9*(1), 10-21. https://www.jstor.org/stable/45410142

Schirmer, B. R., & Lockman, A. S. (2022). Culturally responsive teaching in an undergraduate online general education course. *Online Learning, 26*(3), 132-148. https://doi.org/10.24059/olj.v26i3.2805

Sithithaworn, P., Andrews, R. H., Nguyen, V. D., Wongsaroj, T., Sinuon, M., Odermatt, P., et al. (2012). The current status of opisthorchiasis and clonorchiasis in the Mekong Basin. *Parasitology International, 61*(1), 10-16. https://doi.org/10.1016/j.parint.2011.08.014

Sousa, D. A. (2016). *How the brain learns* (5th ed.). Corwin Press.

Sripa, B., Bethony, J. M., Sithithaworn, P., Kaewkes, S., Mairiang, E., Loukas, A., et al. (2011). Opisthorchiasis and Opisthorchis-associated cholangiocarcinoma in Thailand and Laos. *Acta Tropica, 120*. https://doi.org/10.1016/j.actatropica.2010.07.006

Sripa, B., Tangkawattana, S., & Sangnikul, T. (2017). The Lawa model: A sustainable, integrated opisthorchiasis control program using the EcoHealth approach in the Lawa Lake region of Thailand. *Parasitology International, 66*(4), 346-354. https://doi.org/10.1016/j.parint.2016.11.013

Thomas, M. S. C., Ansari, D., & Knowland, V. C. P. (2019). Annual research review: Educational neuroscience: Progress and prospects. *Journal of Child Psychology and Psychiatry, 60*(4), 477-492. https://doi.org/10.1111/jcpp.12973

Tokuhama-Espinosa, T. (2011). *Mind, brain, and education science: A comprehensive guide to the new brain-based teaching*. W.W. Norton & Company.

Tokuhama-Espinosa, T. N. (2008). *The scientifically substantiated art of teaching: A study in the development of standards in the new academic field of neuroeducation (Mind, Brain, and Education Science)*. Capella University.

Tommerdahl, J. (2010). A model for bridging the gap between neuroscience and education. *Oxford Review of Education, 3*6(1), 97-109. Retrieved from http://www.jstor.org/stable/27784612

Tungkasamit, A., Meekaew, N., Srisurak, P., & Silanoi, L. (2024). School-based training effects on liver fluke and cholangiocarcinoma prevention: A comparative case study of individual differences among elementary teachers in Northeast Thailand. *Journal of Curriculum and Teaching, 13*(1), 272-283. https://doi.org/10.5430/jct.v13n1p272

Unger, J. B., & Schwartz, S. J. (2012). Conceptual considerations in studies of cultural influences on health behaviors. *Preventive Medicine, 55*(5), 353-355. https://doi.org/10.1016/j.ypmed.2012.09.024

van de Kolk, I., Goossens, A. J. M., Gerards, S. M. P. L., Kremers, S. P. J., Manders, R. M. P., & Gubbels, J. S. (2018). Healthy nutrition and physical activity in childcare: Views from childcare managers, childcare workers and parents on influential factors. *International Journal of Environmental Research and Public Health, 15*(12), 2909. https://doi.org/10.3390/ijerph15122909

Wackerle-Hollman, A., Spencer, T. D., Artman-Meeker, K., Kelley, E. S., Durán, L., & Foster, M. E. (2021). Multi-tiered system of supports in early childhood: Identifying gaps, considerations for application, and solutions. *Early Childhood Research Quarterly, 56*, 201-212. https://doi.org/10.1016/j.ecresq.2021.03.010

Acknowledgments

This research was funded by the Cholangiocarcinoma Research Institute, Khon Kaen University. We sincerely thank the Institute for their financial support, which made this study possible. We would also like to extend our gratitude to the Faculty of Education, Khon Kaen University, for their invaluable academic support throughout the course of this research. Our heartfelt thanks go to the students, parents, and educators who participated in and supported this research, as well as the research team for their dedication and hard work.

Authors contributions

Prof. Tungkasamit, Prof. Meekaew, and Prof. Silanoi were responsible for conceptualization. Prof. Tungkasamit and

Prof. Meekaew were responsible for the study design. Prof. Jantaburom and Prof. Boonmee designed research tools. Prof. Tungkasamit, Prof. Meekaew, Prof. Jantaburom, Prof. Boonmee, and Prof. Silanoi were responsible for data collection. Prof. Meekaew and Prof. Tungkasamit were responsible for data analysis. Prof. Meekaew drafted and revised the manuscript. All authors read and approved the final manuscript.

Funding

This work was financially supported by the Cholangiocarcinoma Research Institute, Khon Kaen University.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.