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COMMUNITY-BASED CAPSTONE PROJECTS AS UNIVERSITY–COMMUNITY ENGAGEMENT: AN EXPLORATORY CASE STUDY OF COMMUNITY AQUACULTURE IN MALAYSIA

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Abstract: *Community-based capstone projects offer universities a practical mechanism for connecting academic learning with locally identified needs. However, their educational and social value is often discussed separately from the technical outputs produced by students. This exploratory case study examines a community-engaged capstone project undertaken in community aquaculture at Kebun Komuniti Wanita Taman Mawar, Pasir Gudang, Johor Malaysia. The study resulted in KELI.IO, a portable water-quality observation tool. Rather than evaluating KELI.IO primarily as an engineering system, this study treats it as an actionable community deliverable through which the relationship between community need, academic learning, stakeholder engagement and practical value can be examined. Drawing on capstone education, experiential learning, service-learning, civic engagement, participatory approaches and university–community collaboration, the paper uses an exploratory descriptive case-study approach based on project documentation, field narratives and descriptions of the community setting and implementation process. The evidence indicates that the project provided an authentic problem context, required students to translate disciplinary knowledge into a usable output, and created a practical means of consolidating and communicating selected pond-water observations. The technical documentation further reports a 30-day field observation, scheduled five-minute readings, and selected alert and battery tests; these results are used only as enabling evidence. The study does not establish changes in student learning, community empowerment, fish survival, productivity, income or sustained adoption because no purpose-designed social-science dataset or longitudinal outcome measures were available. The*

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paper concludes with implications for capstone curriculum design, stakeholder participation, reflection, handover, maintenance and future mixed-method research.

Keywords: *community-based capstone; university–community collaboration; community aquaculture;*

Introduction

Capstone projects are commonly positioned as culminating educational experiences through which students integrate knowledge and skills acquired across a programme and apply them to authentic problems. Their educational purpose extends beyond completion of a technical artefact to include critical thinking, communication, teamwork, and preparation for professional practice. When capstones are undertaken with external stakeholders, they also create an opportunity for universities to respond to local needs and for students to encounter the social conditions in which professional knowledge is used (Abdul Halim *et.al.*, 2014 and Kirkscey *et.al.,* 2021*)*. Community-based capstone projects therefore raise a broader social-science question: what happens when the capstone problem is defined not only by an academic curriculum but by an existing community activity? In such projects, students must negotiate from designing for a hypothetical user to designing within a lived setting. The community becomes the context in which relevance, accessibility, responsibility and continuity must be considered. This perspective connects capstone education with experiential learning, service-learning, civic engagement and university–community collaboration (AAC&U, 2014), (Chambers, 1994), (Mackenzie *et.al*., 2019). This paper develops that perspective through a case of community aquaculture at Kebun Komuniti Wanita, Taman Mawar in Pasir Gudang, Johor, Malaysia. The community setting combines crop cultivation with pond-based catfish farming. Existing pond-water checks were described as intermittent and undertaken through separate testing activities, creating a practical need for more accessible and organised observation. KELI.IO, is thus designed as a portable tool that bring selected water observations together with local display, time-stamped records, mobile viewing and threshold notifications. The case is especially useful because the project blends engineering education with community engagement. The study discusses the following issues four questions: (1) structuring capstone project around an identified community need (2) translating technical knowledge into a practical community-oriented deliverable (3) community values can reasonably be identified and (4) challenges in sustaining university–community engagement through technology-based capstone projects

Literature Review

There are five points discussed in the Literature Review (LR):(1) Capstone projects as high-impact educational experiences (2) experiential learning, service-learning and civic engagement (3) university–community collaboration (4) actionable community deliverables and (5) conceptual framework

Capstone Projects as High-Impact Educational Experiences

Capstone experiences are widely understood as culminating opportunities for students to synthesise prior learning and apply it to complex tasks. An international multidisciplinary study identifies academic skill development, preparation for post-graduation life and employment, and a meaningful culminating experience as recurring purposes of capstone education (Kirkscey *et.al., 2021)*. These purposes encompass inquiry, analysis, communication, critical thinking, teamwork and student engagement. Malaysian and international capstone literature

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similarly emphasises the role of the final project in integrating disciplinary knowledge and preparing students for professional practice (Abdul Halim *et.al.,* 2015, Bukhari *et.al.*, 2024, and Deepamala and Shobha, 2019). In engineering and technology education, however, capstone assessment can become strongly product-centred. The quality of a prototype, system architecture or demonstration is important, but it does not capture learning that occurs during problem definition, stakeholder interaction, adaptation to resource constraints and reflection on consequences. A community-based capstone broadens the object of learning from 'can students build it' to ‘can students understand the problem, develop a responsible response, communicate it and consider what happens when it enters a real setting’.

Experiential learning, service-learning and civic engagement

Community-oriented capstones share important characteristics with experiential and service-learning. Students learn through engagement with real-life setting rather than a simulated academic problem. Service-learning connects academic activity to an identified community need and emphasises reflection on the relationship between disciplinary knowledge and community value (AAC&U, 2014 and Mackenzie *et.al*., 2019). This framing means that the community is not simply a recipient of student expertise; its practices, constraints and priorities provide the context within which academic knowledge is applied. Civic engagement adds an ethical dimension. Students encounter the consequences of professional decisions when their work is situated in a community. For technology-oriented projects, this includes considering accessibility, maintenance capacity, communication, local ownership and the ability of users to interpret and act on information. Thus, a community-based capstone can provide a form of professional socialisation in which technical competence is considered alongside responsibility.

Participation and university–community collaboration

Participation emphasises the importance of local knowledge and stakeholder involvement in community initiatives (Chambers, 1994, Pretty, 1995 and Reed, 2008). Community partners contribute practical knowledge of routines and constraints, while universities contribute disciplinary expertise, student effort and research capacity, thus can create reciprocal values. Technology acceptance perspectives further suggest that usefulness depends on ease of use and facilitating conditions (Venkatesh, 2003). In a community project, these concepts translate into questions such as who can read the output, who receives alerts, who maintains the device, and whether the technology fits existing routines. Dialogues, trust and shared understanding, reinforces the need to consider roles and responsibilities rather than assuming that supplying a tool automatically creates community capacity (Ansell and Gash, 2008, and Reed, 2018).

Actionable community deliverables

A defining feature of a community-based capstone is the production of something intended for use outside the classroom. Outputs may include intervention plans, recommendations, educational resources, digital platforms, prototypes or implementation roadmaps. Their educational significance lies in requiring students to translate disciplinary concepts into forms that are understandable and usable within a social setting. In this paper, KELI.IO is therefore conceptualised as an actionable community deliverable rather than the central technological contribution. Its significance lies in the pathway by which a monitoring difficulty was translated into a practical output embedded in an existing community activity.

Conceptual framework

Synthesising the literature and the case evidence, the study proposes a six-stage community-based capstone pathway: (1) Community Need; (2) Community-Engaged Capstone; (3)

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Application of Academic Knowledge; (4) Actionable Community Deliverable; (5) Student Learning and Community Practical Value; and (6) Sustained University–Community Engagement. The first five stages can be examined within the present case, although the evidence for learning and community value is preliminary. The sixth stage is explicitly aspirational because the project did not collect longitudinal evidence of continued use. The framework is intentionally non-deterministic. A community need does not automatically produce social value simply because a capstone is completed. Each transition depends on contextual fit, communication, participation, usability, responsibility and continuity. This allows the framework to function as an analytical model for future studies rather than as a claim of causal impact.

Methodology

The methodology section will explore the research design and case setting, sources of evidence and analytical approach

Research Design and Case Setting

The study adopts an exploratory descriptive case-study design. The case is the community-based capstone project undertaken in relation to catfish farming at Kebun Komuniti Wanita Taman Mawar. The purpose is to understand the project as an educational and university–community engagement process rather than to test the technical performance of the monitoring system. The community site is located in Pasir Gudang, Johor, an urban-industrial locality in southern Malaysia. Community activities include crop cultivation and pond-based catfish farming. Water sources include municipal supply and collected rainwater. Before the capstone intervention, pond-water checking was described as intermittent and dependent on separate testing activities. This provided an authentic problem context for students.

Sources Of Evidence and Analytical Approach

The analysis draws on the descriptions of the community setting, project process, photographs of the developed output, reported field narratives and technical/project summaries. The evidence was organised to reconstruct the pathway from community problem to capstone deliverable and to identify educational, community and continuity implications. No structured student pre/post survey, formal student reflection instrument, community satisfaction questionnaire, systematic interview protocol, complete participant profile, complete raw time-series dataset or longitudinal socioeconomic and biological outcome measures were available. Consequently, the paper does not quantify changes in learning, civic attitudes, community empowerment, income, fish survival or productivity. Technical performance results were treated as enabling evidence only when necessary to explain what the deliverable could do. This separation prevents technical functionality from being interpreted as evidence of social impact. Interpretation follows an evidence hierarchy. A completed feature demonstrates that an output exists; a reported test result indicates performance under the documented condition; and a community benefit is inferred only where the evidence plausibly connects the output with improved access, visibility, communication or response.

Case Study: From Community Need to Capstone Deliverable

Identifying an authentic community need

The project began with an observable difficulty in routine community aquaculture management. Pond conditions were checked through separate and intermittent methods, limiting continuity and making it difficult to see changing conditions as a sequence. From a capstone perspective,

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the importance of the problem lies in its location within an existing community activity rather than in a laboratory exercise or lecturer-defined specification. The community setting also created constraints that a classroom problem might not reveal. A proposed solution needed to be sufficiently accessible for non-specialist users, compatible with routine pond activities and realistic in terms of maintenance. This transformed the project from a purely technical design task into a contextual problem-solving exercise.

Translating academic knowledge into practice

Students drew on knowledge associated with sensing, embedded systems, data handling and digital communication. In this study, these technical elements are treated as learning resources rather than as the principal research contribution. The educational significance lies in the need to combine and constrain those resources around a stakeholder problem. The process required students to move from knowing disciplinary concepts to deciding how those concepts could be integrated and communicated in a real application. Students also had to consider questions that are less visible in conventional classroom exercises: where a device should be placed, who should view the information, what an unusual observation means, who should respond, who is responsible for routine care and what happens when the student project ends.

KELI.IO as an actionable community deliverable

KELI.IO is a portable observation tool that consolidates pH, total dissolved solids (TDS) and temperature readings in one unit, with an on-device display, time-stamped records, mobile viewing and threshold notifications. Its role in this social-science analysis is to provide a tangible example of how an academic capstone can result in a community-facing output. The project documentation reports a 30-day field observation with readings scheduled every five minutes, equivalent to 8,640 scheduled observation cycles, as well as an 86-hour battery endurance test. It also reports notification delivery within six seconds during induced threshold trials. Field narratives describe changes associated with rainfall, hot weather and water-management conditions, including two reported events followed by operator action. These figures and narratives demonstrate that the output was exercised beyond a single classroom demonstration, but they do not establish complete data capture, causal effects or social impact. The deliverable also demonstrates the importance of information design. A local display supports observation at the pond, while mobile viewing extends access away from the device. Notifications function as prompts for human attention rather than automated diagnoses or treatment instructions. The social value of these features therefore depends on whether users can interpret the information and whether response roles are clear. The user interface of the KELI.IO system can be seen in **Figure 1** and the application of the KELI.IO system on catfish pond can be seen in **Figure 2**

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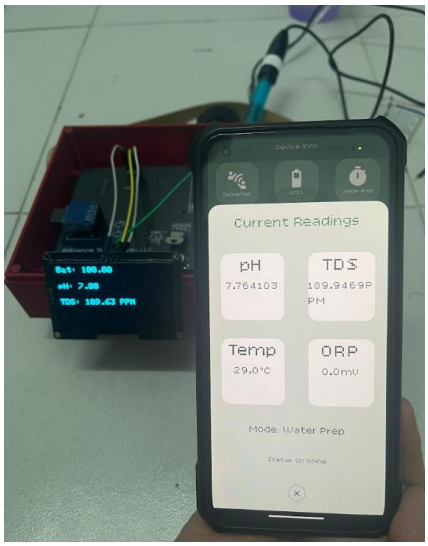


Figure 1: The User Interface of the KELI.IO System



Figure 2: The KELI.IO System Application on Catfish Pond

Educational and Community Value

Authentic problem-based learning

The strongest educational value supported by the case is authenticity. Students worked with a problem embedded in an operating community environment rather than a fully controlled classroom scenario. The setting required consideration of uncertainty, resource limitations, user practices and environmental variation. Such conditions provide opportunities for students to connect disciplinary learning with professional problem solving.

Communication beyond a technical audience

Community engagement requires students to explain the purpose and use of a project in language meaningful to non-specialists. A water-quality value has limited practical value if users cannot recognise what it represents or when attention may be required. Translating technical information into accessible communication is therefore an important component of learning.

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Teamwork, responsibility and professional awareness

A multi-student capstone requires coordination, documentation, integration and field activity. The community context adds responsibility because the output enters a real stakeholder environment. Students must consider reliability, clarity, maintainability and the limits of what the project can legitimately claim. These requirements support broader capstone purposes of teamwork, professional readiness and ethical awareness.

Practical value for the community

The most defensible community value identified in the available evidence is improved accessibility and organisation of selected pond-condition information. KELI.IO consolidated observations that had previously been obtained separately and provided a basis for routine awareness and discussion. In this bounded sense, the project represents a form of community service in which university knowledge and student effort were directed toward a locally situated activity.

Mutual value in university–community engagement

The case illustrates potential reciprocity. The community gained an applied project output and interaction with university personnel, while students gained access to an authentic setting that exposed them to constraints not easily reproduced in a laboratory. This reciprocal possibility distinguishes community-engaged capstone work from a one-directional technology demonstration. However, the depth of reciprocity cannot be quantified from the available evidence.

Discussion

Reframing the capstone from product completion to community engagement

The central contribution of the case is conceptual rather than technological. It demonstrates how a capstone can be interpreted as a form of university–community engagement in which technical production is embedded within a social context. Under this framing, a project is not evaluated only by whether the final artefact functions. Attention is also given to how the need was identified, how academic knowledge was translated, how the output fits local practice, what students learned through engagement, and what responsibilities remain after project completion. This distinction is particularly relevant to interdisciplinary scholarship. Engineering evaluation asks questions about measurement accuracy, system architecture and performance. Social-science evaluation asks how needs are framed, how knowledge is translated, how stakeholders experience the project, how responsibility is distributed and whether a deliverable remains meaningful within local practice. The two perspectives can complement one another without being conflated.

A responsible community-engaged capstone pathway

The case supports the following pathway: Community Need → Community-Engaged Capstone → Application of Academic Knowledge → Actionable Community Deliverable → Student Learning and Community Practical Value → Sustained University–Community Engagement.
The first transition requires that the problem be grounded in an actual community activity. The second and third require students to apply disciplinary knowledge while responding to contextual constraints. The fourth produces an output that can be used or interpreted outside the classroom. The fifth involves learning and practical value, both of which should be assessed rather than assumed. The final transition depends on ownership, maintenance, training, communication and institutional continuity. Importantly, the pathway is not causal by default.

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A project can fail at any transition. A genuine need may be poorly understood; a technically sound design may be unusable; a usable device may lack an owner; and a successful student project may end when the semester ends. The framework therefore identifies points for evaluation rather than promising automatic impact.

Participation and ownership

The project was primarily researcher and student-led. Although the community context informed the problem and practical requirements, the available evidence is insufficient to claim formal co-design, empowerment or shared governance. This is an important finding for the broader community-capstone literature: locating a student project in a community is not equivalent to developing the project with the community. Future iterations could involve community members earlier in problem prioritisation, selection of useful indicators, definition of response procedures and evaluation of the deliverable. Such involvement would move the relationship from a project delivered to a community toward a project developed with a community, consistent with participatory approaches.

Sustainability after the capstone

Continuity is a major challenge because academic projects operate on fixed semesters whereas community needs continue. A useful deliverable can lose value if there is no arrangement for charging, calibration, training, troubleshooting, replacement or decision-making. Sustainable community-based capstones should therefore include an explicit transition plan identifying ownership, routine care, points of contact and realistic institutional support. For a project such as KELI.IO, practical arrangements could include a named community device steward, a simple response guide, a rotating observation role and periodic university support during the transition to local operation. These arrangements should be developed with the community rather than imposed as generic requirements.

Implications for capstone curriculum design

The case supports incorporating community-engagement elements explicitly into capstone design and assessment. A community-based capstone brief could require: (1) a stakeholder-need statement; (2) evidence of engagement; (3) an actionable community deliverable; (4) reflection on social and ethical implications; (5) documentation of communication with non-specialist users; and (6) a sustainability or handover plan. Assessment rubrics could retain technical criteria while adding communication, stakeholder responsiveness, contextual problem definition, reflection and responsible implementation. Such an approach would make community engagement an intentional learning outcome rather than an incidental benefit.

Limitations and Future Research

The principal limitation is the absence of a purpose-designed social-science dataset. The original project was undertaken primarily as an engineering capstone, and the available documentation does not include validated questionnaires, systematic interviews, focus-group transcripts, structured student reflection instruments, complete participant characteristics or longitudinal community outcome measures. The present paper therefore provides an exploratory case interpretation rather than an empirical evaluation of service-learning effectiveness. A future study should prospectively evaluate community-based capstones using mixed methods. Student measures could examine perceived learning, teamwork, communication, civic responsibility, professional confidence and reflective learning before and after the project. Community participants could be interviewed about relevance, usability, trust, participation, maintenance burden and perceived value. Observation could document how

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decisions are negotiated among students, supervisors and community members. Longer-term follow-up should examine whether a deliverable remains in use after student completion, who assumes responsibility, what forms of maintenance are required and whether the relationship leads to subsequent university–community activities. A comparison across several community-based capstones would also help identify which project structures are associated with stronger learning and engagement outcomes. For the aquaculture case specifically, future evaluation could combine social indicators with technical and operational measures, including uptime, verified sensor error, alert receipt, response time, intervention type, water-management changes, operating cost and, where appropriate, biological outcomes. Technical extensions should be introduced only when they address a prioritised community need and can be maintained locally.

Conclusion

This paper reframes the KELI.IO initiative as a case of community-based capstone learning and university–community engagement rather than primarily as an engineering system evaluation. The project originated from a practical monitoring difficulty within community catfish farming and required students to translate disciplinary knowledge into a tangible output situated in a real stakeholder environment. The case supports the proposition that community-based capstones can connect academic synthesis with authentic problem solving, communication, professional responsibility and practical community relevance. The most defensible evidence concerns the authenticity of the problem, application of academic knowledge and production of an actionable deliverable.The broader implication is that community-based capstones should be designed and evaluated as more than product-completion exercises. Their value depends on the quality of the relationship between academic learning and community need, the usability of the deliverable, meaningful stakeholder participation, student reflection and arrangements for continuity after the academic project ends. The proposed community-engaged capstone pathway offers a basis for future research that moves from descriptive case studies toward systematic evaluation of learning, reciprocity, participation and sustained social value.

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