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RESEARCH ARTICLE

CULTIVATING SELF-EFFICACY IN UNIVERSITYSCIENCE AND TECHNOLOGY STUDENT CLUBS

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Abstract

A survey of 98 members of university science and technology clubs found innovative behavior uneven: idea generation scored 4.52, implementation 4.34, dissemination 4.31, overall 4.39. Self-efficacy, 3.29 of 4, positively predicted it. Reading this pattern as easy to think up, harder to carry out, and hardest to make visible, the article proposes four pathways: artifacts over events, support to people over equipment, tiering tasks by stage, and making senior members visible as models, along with enabling conditions.

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Introduction:-

University science and technology clubs in Chinese higher education are usually described as second-classroom activities, yet students join them for something specific: the chance to build a device that runs, to enter a competition with something finished, or to repair equipment others have abandoned. The knowledge involved lives in materials, instruments and repeated failure, and cannot easily be reproduced in a lecture hall. Research on undergraduate innovation has identified conditions that favor it, such as innovation culture operating through self-efficacy [1], interpersonal and moral support rather than equipment alone [2], and a climate that permits constructive disagreement [3]. Those studies ask whether a student is innovative, however, not how an intention becomes a finished object; efficacy research, for its part, has been conducted mostly in academic settings. Drawing on a survey of 98 members in which idea generation scores well above implementation and dissemination, this paper interprets the gap through the mechanisms by which efficacy beliefs form [4] and proposes four pathways, the conditions they require, and the ways they commonly lose their shape. The evidence is cross-sectional, self-reported and drawn from a single institution, so the account offered here is a set of propositions to be tested rather than established effects.

A gap worth noticing:-

What draws students to science and technology clubs is, above all, the chance to make something with their own hands. Yet among the 98 members surveyed, innovative behavior averaged 4.39 on a five-point scale, with idea generation at 4.52, implementation at 4.34 and dissemination at 4.31. The three dimensions form a gradient: easiest to think something up, next to carry it out, hardest to make it visible. The spread between the first and the last is 0.21, which is not large on the scale but, translated into people, means that a considerable portion of members stop

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at the stage of "having an idea." They can propose a plan, but they do not turn it into something that runs and can be demonstrated, still less into something seen by people outside the club. Self-efficacy stood at 3.29 on a four-point scale, moderately high; first-year members reported the highest efficacy (3.36) yet scored lower than fourth-year members on implementation and dissemination.

The gap points to one thing: clubs do not lack ideas; they lack the process through which an idea is made real and shown to others. Ideas can arise from interest and conversation. Making them work means confronting equipment, schedules, technical detail and repeated failure, and if any link in that chain jams, a member's judgment of "whether I can actually do this" slides downward. The two scales use different ranges, so 4.39 and 3.29 cannot simply be subtracted; but the direction of the two figures is consistent. Members rate themselves higher on concrete tasks than on themselves in general, which suggests that their confidence remains at "this is something I could try" and has not settled into "when it gets hard, I can carry it through."

This gap is not a matter of attitude. If members simply did not want to do the work, idea generation would not score so high. The structure of the scores says they are willing to think, and that they retreat at the moment the idea is handed over to reality. Understanding this keeps the pedagogical effort from being spent on repeated exhortation and directs it instead to the concrete conditions under which "thinking" becomes "making."

How self-efficacy operates in the club setting:-

Self-efficacy is a person's judgment of their capacity to perform a given task. It shapes what they choose to attempt, how much effort they invest, and how long they persist after setbacks. For club members this judgment does not arise from abstract introspection but from concrete experience: whether a solder joint held, whether a program ran, whether anyone stopped at their display table. According to the mechanisms through which efficacy beliefs form, such judgments have four principal sources: having succeeded at a task oneself (mastery experience), seeing people similar to oneself succeed (vicarious experience), being told explicitly by someone that one can do it (verbal persuasion), and the arousal experienced in the task itself [4]. Of the four, the first two are the most potent, and they depend most on authentic tasks and observable others, which is precisely what a club provides by nature and a classroom provides with difficulty.

Existing research offers corroboration. Innovative self-efficacy moderates the relationship between a university's innovation culture and graduate students' innovative behavior [1]. A survey of undergraduates found that interpersonal and moral support raised innovative behavior, whereas instrumental support alone had no significant effect [2]. The ways members argue within a club, and the climate those exchanges create, likewise shape whether they are willing to speak and to try [3]. The room for intervention thus becomes clear: not more equipment, but repeated experience of "I can do this" inside real tasks that carry feedback.

The temporal dimension deserves more attention. Efficacy operates on behavior in two stages: one determines whether a person begins, the other whether they continue after a setback. The common failure in a club is not that nobody signs up; it is that those who signed up disappear after the third failed debugging session. Interest and novelty can carry the first stage. The second can only be carried by evidence, by whether the last failure was actually resolved.

What is distinctive about the club setting is that feedback is fast and failure is cheap. A failed solder joint takes minutes to redo; a program error can be traced the same evening; a ruined artifact costs far less to remake than a failed course. Clubs are therefore among the densest sites of mastery experience, and equally dense in failure. Without someone present to explain the failure, that density of frustration depresses members' judgments of themselves faster than it builds them. This is why "support reaching people" matters more than "more equipment."

Four workable pathways:-

Organize the work around artifacts, not events:-

Events end quickly; artifacts remain. A semester's goal can shift from holding a certain number of events to completing a few presentable artifacts: a sensor device, a reproducible dataset, an operating manual. The artifact should be small enough to finish within a semester and difficult enough to require crossing one or two genuine obstacles. The experience of success comes from crossing those obstacles, not from being looked after throughout. Concretely, the semester can open with an artifact list in which each item states its acceptance criteria: it can be demonstrated, it can be reproduced, and its principle can be explained. A mid-term review of half-finished work

follows, at which an incomplete artifact is acceptable but the next step must be stated. The semester closes with a public showing, with the artifacts placed where people outside the club can see them.

The hard part of artifact-based work is choosing the topic. Too large, and the semester cannot contain it, so members hand in half-finished work at the deadline and confirm their own sense of "I can't." Too small, and no obstacle is crossed, so finishing yields little sense of capacity. The feasible scale is roughly "one semester, two or three people, one thing that can be demonstrated," and the thing must include one genuine failure and its revision, recorded in the artifact file.

Direct support to people, not only to equipment:-

Equipment and space constitute instrumental support. They lower the threshold, but they do not necessarily change how members judge themselves [2]. What works is the presence of someone: a regular instructor, a paired senior member, specific feedback after each debugging session. Feedback should point to actions and technical detail; "the wiring order was wrong this time, draw the diagram first next time" builds more perceived capacity than "you're already great." In practice the instructor does only three things: sets the standard, gives feedback, and absorbs failure. The standard tells members what counts as passing; feedback makes errors locatable; absorbing failure keeps a mistake from becoming an unbearable cost.

Feedback also needs a record. A spoken remark is easily forgotten; comments written into a "debugging log" accumulate into method: how often the same error has occurred, how it was eventually resolved, what to check first next time. Trivial as such records seem, they are the smallest unit through which individual experience becomes transferable knowledge, and the most direct teaching material for a newcomer.

Tier the work by stage, giving each cohort its own task:-

First-year members need low-threshold entry tasks and room to fail; their efficacy is high and their experience thin, and what they fear most is being judged unsuitable after a single failure. Second- and third-year members need project training, learning schedule management, technical norms and division of labor; implementation capacity is largely formed at this stage. Senior members should lead teams, present externally and consolidate experience, turning what they have gained into the club's shared assets. Tiering is not labeling; it is making sure each person holds a task slightly above their current capacity and still within reach.

Tasks can be configured along three levels: imitate, improve, define. First-year members begin with reproduction, building the same thing from an existing drawing and code and learning the tools and norms. Second- and third-year members improve, replacing a module or resolving a specific defect in an existing artifact and learning to schedule and collaborate. Senior members define, deciding what should be done and whether it is worth doing, and bringing one or two newcomers along until it is done. The threshold between levels should be stated plainly, so that members know where they stand and what the next step up requires.

Make senior members visible as models:-

A member's judgment that "I can do this" comes largely from "someone like me did it." The senior member's technique need not be the best, but the process must be imitable: how to look things up, how to troubleshoot, how to adjust after failure. The club should make that process public, through regular reviews, artifact files and pairing between newcomers and seniors, so that tacit experience becomes a visible route.

The review can be light in form: twenty minutes each week, with one member presenting a case of failure, what they set out to do, where they were stuck, and how they eventually got around it. Talking about failure models more than talking about success, because what it shows is precisely how capacity grows. Artifact files, for their part, record each version and key decision, so a newcomer who leafs through them learns how many rounds a thing passes through before it becomes usable.

Conditions for the pathways to hold:-

None of the four pathways is complicated; the difficulty lies in sustaining them. The first condition is time and space: clubs need fixed opening hours rather than borrowed laboratory time, and consumable budgets should be set per artifact rather than per event, since artifacts are tried and retried and consume far more than a single display does. The second is staffing. Instructors' workload must be recognized, or guidance will survive only on individual goodwill; senior members' mentoring should count toward internal contribution records rather than remaining purely voluntary.Then there is safety and handover. Equipment use requires induction training and operating rules,

especially where electricity, cutting and high temperature are involved; this protects members and also allows parents and the institution to let go. Handover concerns continuity: each artifact should leave behind drawings, code, a consumables list and the pitfalls encountered, so that the project does not disperse when the people do. Without these two provisions, artifact-based work tends to return to zero when a cohort graduates.

Ways the approach loses its shape:-

The first is turning artifacts into a task list. Counting outputs without checking completion, members can hand in ten half-finished pieces and never have the experience of "I made this." The core of artifact-based work is completion and public verification, not output volume.The second is turning feedback into praise. When evaluation points at the person rather than the action, members hear only that they are wonderful and remain helpless before a specific fault. Feedback matters because it makes an error locatable and remediable.

The third is turning tiering into screening. Barring first-year members from projects on the grounds that their capacity is insufficient looks efficient but deprives them of the chance to accumulate their first experience, and narrows the club's talent pool year by year.The fourth is turning models into publicity. Showing only prizes and finished products, never the process and the failures, leaves members seeing that "others are simply born able," which reinforces their sense of "I am not." An imitable model must include the struggling part.

Conclusion:-

The educational value of a science and technology club lies not only in skills taught but in whether a member completes, here, the full passage from idea to finished product, and thereby comes to believe they can finish the next one.In this sense the unit of evaluation should not be the number of events held but completeness: how many artifacts were genuinely brought to completion this year, publicly demonstrated, and carried forward by those who came after. The numbers need not look impressive, but each artifact should be able to explain how it traveled from idea to product, how many times it failed along the way, and who helped resolve the problem.

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