Jurnal Guru Dikmen dan Diksus
Volume 6 Number 2, 2023. Page 169-178
p-ISSN: 2655-481x, e-ISSN: 2723-6404

Hydroponic Media as an Innovation for Collaborative Learning at SMA Negeri 17 Garut

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(Received: June 10, 2022; Accepted: October 25, 2022; Published: December 30, 2023)

ABSTRACT

Twenty-first-century education requires students to develop collaboration alongside critical thinking, creativity, and communication. This study examined the relationship between the use of hydroponic media and collaborative learning at SMA Negeri 17 Garut. A quantitative correlational design was employed with 50 students from Grades X, XI, and XII. Data were collected through a Google Forms questionnaire consisting of ten items for hydroponic-media use and ten items for collaborative learning, and were analyzed using descriptive statistics, Pearson correlation, reliability testing, and simple linear regression in SPSS 26. The instruments were reported as valid, with Cronbach's alpha values of 0.784 for hydroponic media and 0.665 for collaborative learning. The analysis yielded $R = 0.921$ and $R^2 = 0.848$, indicating a strong statistical association between the two variables. The regression equation reported in the source study was $Y = 0.475 + 1.105X$, with $t = 4.428$ exceeding the reported critical value of 2.423. These findings suggest that hydroponic activities can function as a contextual, project-oriented learning environment that supports teamwork, communication, responsibility, and the gotong royong dimension of the Pancasila Student Profile. Because the study is correlational and based on a purposive school sample, the findings should be interpreted as association rather than definitive causal evidence.

Keywords: hydroponics; collaborative learning; project-based learning; 21st-century skills; contextual learning

INTRODUCTION

Contemporary schooling increasingly emphasizes the ability to collaborate, communicate, solve problems, and create knowledge with others. Collaborative competence is not merely a social add-on; it is closely connected with deeper learning, student agency, and the capacity to work productively on complex tasks (Bell, 2010; Dillenbourg, 1999; Johnson & Johnson, 2009; Laal & Ghodsi, 2012; OECD, 2017). Project-based and inquiry-oriented environments are particularly suitable because they organize learning around authentic problems, shared products, and iterative decision making (Kokotsaki et al., 2016; Krajcik & Blumenfeld, 2006; Larmer et al., 2015; Thomas, 2000).

At SMA Negeri 17 Garut, hydroponics has been used as a contextual learning medium since 2019. The school context is strongly connected with agriculture, and the original manuscript reports that approximately 70% of students' parents work as farmers. Hydroponic cultivation therefore provides a

locally meaningful setting in which subject knowledge can be connected with real processes such as seeding, nutrient management, plant growth, harvesting, marketing, and greenhouse maintenance. Such contextualization is consistent with experiential, place-based, and sustainability-oriented education, which emphasizes learning through participation in authentic environments (Kolb, 1984; Gruenewald, 2003; Wals, 2011; UNESCO, 2020).

The study addresses a practical question: whether students' reported experience with hydroponic media is statistically associated with collaborative learning. The original study involved 50 students from Grades X-XII and used questionnaire data analyzed through correlation and simple regression. This article restructures the study in an international academic format while preserving the empirical values reported in the source manuscript.

LITERATURE REVIEW

Collaborative Learning and Twenty-First-Century Competence

Collaborative learning refers to structured learning in which participants coordinate knowledge, responsibilities, and actions toward shared goals. Its theoretical roots include social constructivism, cooperative learning, and socially shared cognition (Vygotsky, 1978; Dillenbourg, 1999; Johnson et al., 2007; Stahl et al., 2006). Effective collaboration requires positive interdependence, individual accountability, interpersonal communication, and opportunities for reflection (Johnson & Johnson, 2009; Gillies, 2016). Research also links well-designed collaboration with achievement, engagement, peer learning, and development of interpersonal competence (Slavin, 2014; Roseth et al., 2008; Hattie, 2009; Scager et al., 2016).

In the Indonesian curriculum context, collaboration aligns with the gotong royong dimension of the Pancasila Student Profile. Internationally, comparable frameworks position collaboration among the core competencies needed for learning and work in complex, technology-rich societies (Trilling & Fadel, 2009; Voogt & Roblin, 2012; van Laar et al., 2017; Care et al., 2018; OECD, 2017). Consequently, learning environments should provide students with repeated opportunities to negotiate roles, communicate evidence, solve practical problems, and produce shared outcomes.

Hydroponics as Contextual and Sustainability-Oriented Learning Media

Hydroponics is a soilless cultivation system in which water and nutrient solutions support plant growth. Beyond agricultural production, school hydroponics can function as a multidisciplinary learning environment linking biology, chemistry, physics, mathematics, economics, entrepreneurship, and language. School gardens and food-growing activities have been associated with experiential learning, environmental awareness, food literacy, and student engagement (Blair, 2009; Williams & Dixon, 2013; Berezowitz et al.,

2015; Ohly et al., 2016; Savoie-Roskos et al., 2017). Hydroponic systems also offer opportunities to investigate resource efficiency, nutrient cycles, water use, urban agriculture, and sustainable food systems (Barbosa et al., 2015; Benke & Tomkins, 2017; Al-Kodmany, 2018; Beacham et al., 2019; Shamshiri et al., 2018).

When hydroponic activities are framed as projects rather than demonstrations, students can distribute tasks, monitor plant conditions, document evidence, troubleshoot system problems, and evaluate products collectively. These features align with project-based learning, where authenticity, sustained inquiry, student voice, reflection, and public products are central design elements (Bell, 2010; Kokotsaki et al., 2016; Condliffe et al., 2017; Guo et al., 2020; Chen & Yang, 2019). Such activities can also contribute to education for sustainable development by integrating ecological, social, and economic considerations (Sterling, 2010; Wals, 2011; Lozano et al., 2017; UNESCO, 2020).

Conceptual Framework

The conceptual model positions hydroponic-media use (X) as the predictor and collaborative learning (Y) as the outcome. The proposed mechanism is pedagogical rather than technological: hydroponics provides a shared, authentic task environment that requires planning, division of labor, communication, joint monitoring, and collective evaluation. This mechanism is consistent with experiential learning (Kolb, 1984), situated learning (Lave & Wenger, 1991), and project-based learning theory (Krajcik & Blumenfeld, 2006).

METHODS

Research Design and Participants

The study used a quantitative correlational design. The research setting was SMA Negeri 17 Garut, West Java, Indonesia. The sample consisted of 50 students from Grades X, XI, and XII in 2022. The source manuscript reports 30 female students (60%) and 20 male students (40%); 20 Grade X students (40%), 25 Grade XI students (50%), and 5 Grade XII students (10%); and an equal distribution of 25 science and 25 social-science students.

Variables, Instrument, and Analysis

Hydroponic media was specified as the independent variable (X), while collaborative learning was specified as the dependent variable (Y). Data were collected using Google Forms. Each construct was represented by ten Likert-type questionnaire statements. Item validity was assessed using item-total Pearson correlations against a reported r-table value of 0.279. Internal consistency was evaluated using Cronbach's

alpha. Descriptive statistics, Pearson correlation, coefficient of determination, t testing, F testing, and simple linear regression were processed using SPSS version 26.

Table 1. Summary of the research design and analytical procedures.

Component	Specification
Design	Quantitative correlational study
Participants	50 students, Grades X-XII
Predictor (X)	Use of hydroponic media
Outcome (Y)	Collaborative learning
Instrument	20 questionnaire items: 10 items per construct
Software	SPSS version 26
Main analyses	Validity, reliability, descriptive statistics, Pearson correlation, R^2, simple regression

RESULTS AND DISCUSSION

Participant Profile and Descriptive Statistics

The sample comprised 50 students. Female students represented 60% of respondents and male students 40%. Grade XI contributed half of the sample, Grade X 40%, and Grade XII 10%. Science and social-science tracks were equally represented. These distributions should be considered when interpreting generalizability because the sample was not described as probability-based.

Table 2. Descriptive statistics reported in the original SPSS output.

Statistic	Hydroponic Media	Collaborative Learning
Mean	16.1800	17.4000
Std. error	0.42348	0.50790
Median	17.5000	19.0000
Mode	19.00	20.00
Std. deviation	2.99448	3.59137
Variance	8.967	12.898
Range	8.00	10.00
Minimum	11.00	11.00
Maximum	19.00	21.00
Sum	809.00	870.00

Validity and Reliability

All ten items for each construct were reported as valid because their item-total correlations exceeded the reported critical value of 0.279. For hydroponic media, item correlations ranged from 0.530 to 0.890; for collaborative learning, they ranged from 0.500 to 0.987. Cronbach's alpha was 0.784 for hydroponic media and 0.665 for collaborative learning. The first value indicates acceptable internal consistency, while the second is more modest and suggests that future studies should further refine the collaborative-learning scale (Taber, 2018; Tavakol & Dennick, 2011).

Table 3. Reliability results reported in the source study.

Construct	Cronbach's alpha	Items	Interpretation
Hydroponic media	0.784	10	Acceptable
Collaborative learning	0.665	10	Moderate / usable with caution

Association Between Hydroponic Media and Collaborative Learning

The reported Pearson correlation was $R = 0.921$ and the coefficient of determination was $R^2 = 0.848$. Thus, the two measured constructs were strongly associated in this sample. The source manuscript interprets R^2 as 84.8% of variation in collaborative learning being associated with hydroponic-media use, with 15.2% attributed to other factors not included in the model. Because the research design is correlational, R^2 should not be interpreted as proof that hydroponic media caused 84.8% of collaborative learning; unmeasured student, teacher, class, and school factors may also contribute.

Table 4. Main correlation and regression results.

Indicator	Reported value
Pearson R	0.921
R^2	0.848
Constant (a)	0.475
Regression coefficient (b)	1.105
t statistic	4.428
Reported t critical	2.423
Regression equation	$Y = 0.475 + 1.105X$

The positive regression coefficient is consistent with the study's central proposition: higher reported engagement with hydroponic learning was associated with stronger reported collaborative learning. This

finding is pedagogically plausible because hydroponic projects require coordinated tasks, shared observation, troubleshooting, and responsibility across a production cycle. Prior research on project-based learning similarly emphasizes that authentic, sustained projects can strengthen communication, teamwork, self-regulation, and disciplinary learning when roles and assessment are deliberately structured (Kokotsaki et al., 2016; Chen & Yang, 2019; Guo et al., 2020).

The school implementation is also notable for its cross-curricular orientation. The original article connects hydroponics with biology, physics, chemistry, mathematics, economics, entrepreneurship, and Indonesian language learning. This interdisciplinary structure can make collaboration visible as an instructional practice rather than an abstract competency. It also situates sustainability learning in a concrete local context, which is consistent with place-based, outdoor, nature-based, and sustainability education (Gruenewald, 2003; Rickinson et al., 2004; Kuo et al., 2019; Sterling, 2010; Lozano et al., 2017).



Figure 1. Hydroponic learning activity at SMA Negeri 17 Garut (source: original manuscript).

Limitations

Several limitations constrain interpretation. First, the design is correlational and cross-sectional, so causal claims should be avoided. Second, the sample consisted of 50 students from one school and included class leaders and extracurricular participants, limiting representativeness. Third, both variables were measured through self-report questionnaires, which may inflate associations through common-method variance. Fourth, the collaborative-learning scale showed only moderate internal consistency ($\alpha = 0.665$). Finally, the source manuscript contains an inconsistency in the reported F statistic: one table presents F =

26.8, whereas the narrative later reports F = 268.7. Because the underlying SPSS output was not available for verification, this article does not resolve that discrepancy and recommends checking the original dataset/output before publication.

CONCLUSION AND RECOMMENDATIONS

The study found a strong positive association between the use of hydroponic media and collaborative learning among 50 students at SMA Negeri 17 Garut. The reported correlation was R = 0.921, with R^2 = 0.848, and the simple regression equation was Y = 0.475 + 1.105X. Hydroponic activities appear to provide a meaningful contextual environment for teamwork, communication, shared responsibility, and gotong royong. Schools may therefore use hydroponic projects as interdisciplinary learning media, particularly when teachers coordinate learning objectives, student roles, assessment criteria, and reflection across subjects. Future research should use larger and more representative samples, validated collaboration instruments, pretest-posttest or quasi-experimental designs, direct observation of collaborative behavior, and verified statistical output to test whether the observed association reflects a causal instructional effect.

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