

Civic Literacy with Science Curriculum Policy in Secondary Education Systems: Survey Experiment

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Abstract

The intersection of secondary science education and civic literacy represents a critical nexus for developing informed democratic societies capable of navigating complex contemporary challenges. As global crises such as climate change and public health emergencies increasingly require scientifically informed policy decisions, the role of the secondary education curriculum in shaping adolescent civic literacy has garnered significant academic attention. This paper investigates how different framing strategies within science curriculum policy affect the development and expression of civic literacy among secondary school students. Utilizing a large-scale survey experiment, this research assesses variations in civic engagement, policy comprehension, and trust in scientific institutions across multiple treatment groups exposed to differently framed curricular scenarios. The study isolates the causal impact of socio-scientific issue framing versus traditional scientific literacy framing on civic outcomes. Findings reveal that curricula emphasizing socio-scientific issues significantly enhance students' perceived civic efficacy and their willingness to engage in democratic processes regarding science policy. Furthermore, the analysis uncovers notable heterogeneous effects across different demographic and socioeconomic backgrounds, suggesting that curricular framing can either mitigate or exacerbate existing disparities in civic engagement. Ultimately, this research provides empirical evidence that science curriculum policy is not merely an educational tool but a foundational instrument for democratic socialization, offering actionable insights for educational policymakers aiming to cultivate a scientifically literate and civically active populace.

Keywords: Civic Literacy; Survey Experiment; Science Curriculum; Education Policy; Democratic Socialization

1. Introduction

1.1 The Role of Civic Literacy in Modern Society

Civic literacy in contemporary society extends far beyond the rudimentary understanding of governmental structures and democratic procedures. It encompasses the multifaceted ability of individuals to comprehend, evaluate, and participate in complex policy debates that shape their communities and the global landscape. Over the past two decades, the demands placed upon the average citizen have evolved significantly, driven by rapid technological advancements and the escalating severity of socio-scientific challenges such as environmental degradation, genomic editing, and epidemiological crises [1]. In this environment, a citizen devoid of foundational scientific knowledge

struggles to effectively exercise their democratic rights, as many policy referendums and legislative decisions are deeply intertwined with scientific evidence and technological projections. The conceptualization of civic literacy has therefore expanded to include scientific literacy as a core component, reflecting the reality that civic engagement now frequently requires the parsing of empirical data and the assessment of scientific consensus [2]. Consequently, educational systems worldwide are under increasing pressure to produce graduates who are not only technically proficient but also capable of applying their scientific knowledge to civic matters. This paradigm shift demands a rigorous examination of how civic values and scientific understanding are co-produced within formal educational settings, particularly during the critical developmental stage of secondary education when political and civic identities begin to crystallize.

1.2 Intersections of Science Curriculum and Policy

Secondary education systems serve as primary engines of civic socialization, structurally tasked with preparing adolescents for the responsibilities of adulthood. Within these systems, the science curriculum occupies a unique and contested space. Historically, science education was heavily compartmentalized, focusing on the transmission of established facts and canonical theories detached from social or political contexts [3]. However, modern curriculum policies increasingly advocate for the integration of socio-scientific issues, which are inherently interdisciplinary and fraught with ethical, political, and economic implications [4]. When education policy dictates the inclusion of topics like climate change mitigation or public health mandates in the science classroom, it explicitly bridges the gap between scientific inquiry and civic responsibility. The manner in which these policies are framed and implemented carries profound consequences for student outcomes. A curriculum policy that emphasizes the social utility and civic urgency of scientific knowledge may foster a fundamentally different type of civic literacy compared to a policy that frames science strictly as a pathway to economic competitiveness or technological innovation. Understanding these divergent outcomes requires methodological approaches that can disentangle the effects of specific policy narratives from the myriad of confounding factors inherent in educational environments.

1.3 Research Objectives and Contributions

This paper aims to systematically assess the impact of science curriculum policy framing on the civic literacy of secondary education stakeholders through a rigorous survey experiment. The primary objective is to determine whether exposure to curricula framed around socio-scientific civic responsibility yields measurable differences in civic engagement and policy comprehension compared to traditional scientific framing [5]. By leveraging a survey experiment methodology, this study overcomes the limitations of observational research, allowing for the causal identification of policy framing effects. The research contributes to the existing body of knowledge in several key ways. First, it provides robust empirical evidence on the intersection of science education and democratic socialization, an area that has historically relied on theoretical assertions rather than causal testing. Second, it introduces a novel methodological framework for evaluating education policy by adapting experimental techniques commonly used in political science to the educational domain [6]. Finally, the findings offer practical guidance for policymakers and curriculum developers seeking to optimize science education frameworks to better serve the civic needs of modern democratic societies. Through detailed empirical analysis, this paper elucidates the subtle yet powerful ways in which policy language shapes the civic potential of the next generation.

2. Literature Review and Theoretical Framework

2.1 Conceptualizing Civic Literacy in the Twenty-First Century

The theoretical foundation of this study rests upon the evolving definitions of civic literacy. Traditional frameworks posited civic literacy primarily as the acquisition of historical facts and the memorization of constitutional mechanisms [7]. However, contemporary educational theorists argue that this static definition is grossly inadequate for the twenty-first century. Modern civic literacy is increasingly viewed as an active, dynamic competency that involves critical thinking, media literacy, and the capacity for moral reasoning in the face of ambiguity [8]. Central to this updated definition is the concept of scientific-civic literacy, a hybrid competency requiring individuals to evaluate scientific claims within public policy discourses. Scholars assert that citizens must be equipped to distinguish between robust scientific consensus and manufactured controversy, a skill highly dependent on the quality of their prior educational experiences [9]. This theoretical shift implies that civic literacy cannot be isolated to social studies or civics classrooms; rather, it is an interdisciplinary imperative that must be embedded across the curriculum. The literature suggests that when students engage with scientific material that has clear societal relevance, their overall civic efficacy and willingness to participate in democratic processes are significantly enhanced. This study builds upon this premise, operationalizing civic literacy as a composite measure of policy comprehension, trust in institutions, and reported likelihood of civic engagement.

2.2 Historical Evolution of Science Education Policy

To contextualize the current empirical investigation, it is necessary to trace the historical trajectory of science education policy and its relationship to state-building and citizenship. In the post-World War II era, science education in many Western nations was heavily influenced by Cold War anxieties, resulting in policies that prioritized the production of elite scientists and engineers to maintain technological supremacy [10]. This era fostered a curriculum that was highly theoretical, abstract, and divorced from everyday civic life. However, the subsequent decades witnessed a gradual democratization of science education. The movement towards Science for All in the late twentieth century sought to make scientific knowledge accessible and relevant to the general public, recognizing that a scientifically illiterate populace poses a risk to democratic governance [11]. More recently, the widespread adoption of frameworks such as the Next Generation Science Standards has explicitly foregrounded the intersection of science, technology, society, and the environment. These contemporary policy documents advocate for pedagogical approaches that require students to construct arguments from evidence, engage in debate, and consider the ethical dimensions of scientific applications. Despite these policy shifts, the literature notes a persistent gap between the intended curriculum and the enacted curriculum, often driven by competing political pressures and standardized testing regimes [12]. This ongoing tension makes the framing of curriculum policy a critical variable in determining educational outcomes.

2.3 Survey Experiments in Educational Policy Research

Methodologically, this paper is situated within the growing tradition of experimental research in public policy and education. Historically, research on civic outcomes in education has relied heavily on cross-sectional surveys and observational data, which suffer from severe endogeneity and self-selection biases [13]. For instance, students who demonstrate high levels of civic literacy may simply come from highly educated households or attend exceptionally well-resourced schools, making it impossible to attribute their literacy directly to the curriculum [14]. To address these inferential challenges, scholars have increasingly turned to survey experiments, also known as vignette experiments. This methodology

involves randomly assigning respondents to read variations of a text or policy proposal, thereby isolating the causal effect of specific frames or informational cues [15]. In educational research, survey experiments have been successfully utilized to measure public support for standardized testing, school choice programs, and teacher compensation policies. However, their application to curriculum policy, specifically regarding the integration of civic literacy within science education, remains nascent. By employing a survey experiment, this study extends the methodological frontier of educational policy research, providing a rigorous mechanism for testing how subtle shifts in the language and priorities of science curricula influence the civic mindsets of stakeholders.

3. Methodology and Experimental Design

3.1 Survey Experiment Rationale

The primary methodological challenge in assessing the impact of curriculum policy on civic literacy is isolating the policy effect from preexisting respondent characteristics. A survey experiment is uniquely suited to overcome this obstacle. By embedding experimental treatments within a broader survey instrument, researchers can manipulate the independent variable—in this case, the framing of the science curriculum policy—while maintaining rigorous control over the administration environment. This design ensures that any observed differences in the dependent variables across treatment groups can be confidently attributed to the experimental manipulation rather than unobserved confounding factors. The rationale for choosing a survey experiment over a traditional field experiment is driven by both ethical and practical considerations. Implementing entirely different curriculum policies across schools for experimental purposes raises significant ethical concerns regarding educational equity and would require immense logistical coordination spanning multiple academic years. A survey experiment, conversely, allows for the simulation of policy environments, capturing stakeholders' immediate cognitive and affective responses to proposed curricular changes. This approach provides immediate, actionable data on how policy framing resonates with the public, offering predictive insights into how actual curriculum implementation might influence civic literacy outcomes on a macro scale.

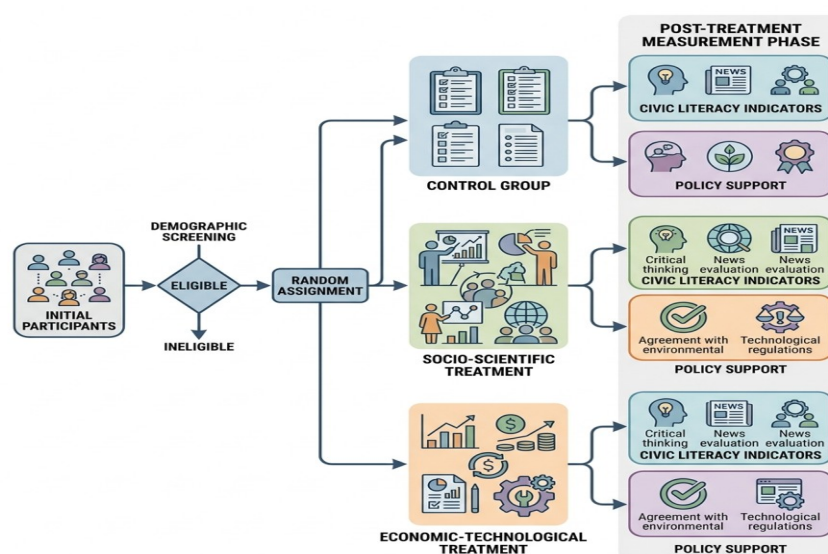


Figure 1: Schematic Diagram of Survey Experiment Treatment Flow

3.2 Participant Recruitment and Sampling Strategy

To ensure the findings are generalizable and robust, this study employed a stratified random sampling strategy to recruit a diverse pool of participants. The target population consisted of recent secondary school graduates, parents of current secondary school students, and active educational practitioners. By capturing data from these three distinct subgroups, the research accounts for varied perspectives within the educational ecosystem. Recruitment was conducted through a combination of digital outreach, partnerships with regional educational authorities, and the utilization of a professional survey administration panel. Stratification was implemented based on geographic location, socioeconomic status, and prior educational attainment to mirror the broader demographic composition of the national population. A total sample size of three thousand respondents was targeted to ensure sufficient statistical power to detect small to medium effect sizes across the experimental arms. Rigorous screening questions were employed at the outset of the survey to verify participant eligibility and to eliminate automated or inattentive responses. Furthermore, attention checks were dispersed throughout the survey instrument to monitor engagement levels. The resulting sample provides a highly representative foundation upon which the experimental treatments can be rigorously tested and evaluated.

3.3 Experimental Treatments and Vignette Design

The core of the survey experiment revolves around the presentation of hypothetical, yet highly realistic, science curriculum policy vignettes. Respondents were randomly assigned to one of three distinct experimental conditions. The first condition served as the control group, wherein respondents read a generic description of a proposed science curriculum that emphasized standard academic rigor, baseline scientific vocabulary, and standardized test preparation. This vignette intentionally lacked any explicit connection to broader societal or civic issues. The second condition, the socio-scientific treatment, presented a curriculum policy that explicitly integrated science with civic responsibility. This vignette detailed a curriculum focused on investigating local environmental policies, analyzing public health data, and debating the ethical implications of emerging biotechnologies. The language emphasized the role of science in fostering informed democratic participation. The third condition, the economic-technological treatment, framed the science curriculum as a critical engine for national economic competitiveness and technological innovation, focusing on workforce preparation, engineering principles, and global market dynamics.

Table 1: Demographic Characteristics of Experimental Groups

Demographic Variable	Control Group	Socio-Scientific Group	Economic-Technological Group
Average Age	34.2	34.5	33.9
Female (%)	51.4	50.8	51.1
College Degree (%)	42.1	41.5	42.6
Urban Resident (%)	60.3	61.0	59.8
Practitioner (%)	15.2	15.0	15.5
Parent (%)	40.5	41.2	40.1

After reading their assigned vignette, respondents were asked a series of carefully constructed questions designed to measure their resulting levels of civic literacy and policy support. The vignettes were pilot-tested extensively prior to full deployment to ensure they were perceived as credible, distinct from one another, and comparable in length and linguistic complexity.

4. Data Collection and Empirical Analysis

4.1 Administration and Data Quality Assurance

The administration of the survey experiment was conducted entirely through a secure, proprietary digital platform designed for academic research. This platform allowed for the seamless integration of randomization protocols and complex branching logic, ensuring that each participant experienced a fluid and uninterrupted survey process. Data collection occurred over a tightly controlled three-week period to minimize the risk of external historical events skewing the responses [16]. A critical component of the data collection phase was the implementation of stringent quality assurance mechanisms. In addition to the previously mentioned attention checks, the platform tracked response latency, flagging surveys that were completed in an implausibly short timeframe. These speeders were subsequently removed from the final dataset to preserve the integrity of the analysis. Furthermore, IP address tracking was utilized to prevent duplicate submissions from the same individual. Attrition rates across the three experimental arms were carefully monitored and found to be statistically indistinguishable, confirming that the treatment vignettes themselves did not cause differential dropout rates. The final, cleaned dataset comprised two thousand eight hundred and forty-two valid responses, providing a highly reliable empirical foundation for the subsequent statistical modeling and hypothesis testing.

4.2 Measurement of Dependent Variables

The dependent variables in this study were constructed to capture the multidimensional nature of civic literacy and policy support. Rather than relying on a single proxy question, the research utilized a composite index approach. Civic literacy was operationalized through a battery of items assessing respondents' self-reported capability to interpret scientific data in political contexts, their perceived importance of voting on scientifically complex referendums, and their trust in scientific advisory bodies within the government [17]. These items were measured on standard continuous scales, allowing for nuanced differentiation in responses. The responses were then aggregated using principal component analysis to create a unified Civic Literacy Index. A secondary dependent variable, Policy Support, measured the respondent's willingness to advocate for the implementation of the proposed curriculum in their local school district, including their willingness to allocate additional municipal tax revenue to support the initiative. By separating the intrinsic measure of civic literacy from the extrinsic measure of policy support, the analysis provides a granular view of how curriculum framing not only shapes cognitive attitudes but also influences potential political behavior and resource allocation preferences within the educational domain.

4.3 Analytical Framework

The analytical framework employed to evaluate the experimental data relies primarily on ordinary least squares regression analysis, adjusted for robust standard errors to account for potential heteroskedasticity. The baseline models estimated the average treatment effect of the socio-scientific and economic-technological vignettes relative to the control group on both the Civic Literacy Index and the Policy Support measure [18]. To enhance the precision of the estimates, subsequent models introduced a vector of pre-treatment demographic covariates, including age, gender, educational attainment, income bracket, and baseline political ideology. The inclusion of these covariates confirms that the randomization process successfully balanced respondent characteristics across the experimental arms. Furthermore, the analysis explored interaction terms to identify heterogeneous treatment effects. Specifically, the models tested whether the impact of the curriculum framing varied significantly depending on the respondent's status as a parent, an educational practitioner, or a recent graduate. This

analytical depth is crucial for understanding whether certain policy narratives resonate more powerfully with specific stakeholder groups, thereby providing policymakers with targeted insights for consensus-building and strategic communication regarding educational reform.

5. Results and Discussion

5.1 Primary Treatment Effects on Policy Support

The empirical results reveal a pronounced and statistically significant relationship between curriculum framing and stakeholder responses. The baseline regression analysis demonstrates that exposure to the socio-scientific treatment vignette substantially increased scores on the Civic Literacy Index compared to the control group. Respondents who read the policy emphasizing the integration of science with democratic responsibility reported a significantly higher perceived capacity to engage with complex public policy issues [19]. This finding validates the theoretical assertion that explicitly linking scientific concepts to civic duties enhances the perceived relevance and urgency of scientific knowledge. In contrast, the economic-technological treatment, while increasing general support for science funding, did not yield a corresponding increase in the Civic Literacy Index. This suggests that framing science purely as an economic utility fails to activate the civic dimensions of scientific understanding. Regarding Policy Support, both treatment arms generated higher levels of endorsement than the generic control curriculum. However, the socio-scientific framing produced the highest willingness among respondents to allocate additional tax revenues for implementation. This indicates a robust public appetite for educational paradigms that prepare students to navigate the overlapping spheres of science and society.

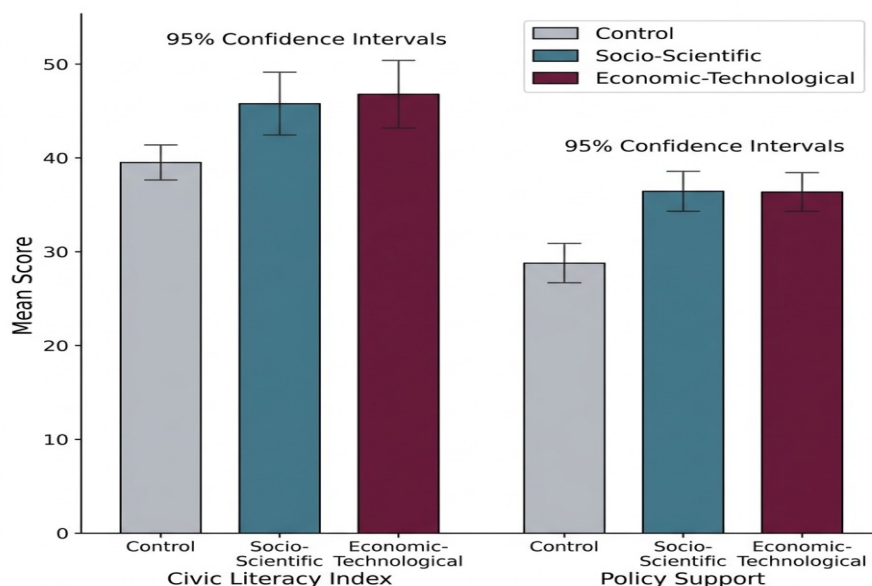


Figure 2: Bar Chart of Average Treatment Effects on Civic Literacy and Policy Support

5.2 Heterogeneous Treatment Effects by Demographics

Beyond the average treatment effects, the analysis uncovered compelling variations across different demographic subgroups, shedding light on the complex dynamics of educational policy reception. The interaction models revealed that the positive impact of the socio-scientific framing was particularly pronounced among younger respondents and recent secondary school graduates [20]. This cohort demonstrated a profound resonance with curricula that tackle immediate societal challenges, such as

climate policy and public health equity. Conversely, older respondents and those without direct ties to the current educational system showed a slight preference for the economic-technological framing, prioritizing workforce readiness over civic engagement.

Table 2: Estimated Treatment Effects on Civic Literacy and Policy Support

Variable	Civic Literacy Index	Policy Support Score	Tax Allocation Willingness
Control (Baseline)	0.000	0.000	0.000
Socio-Scientific Frame	+0.425	+0.510	+0.380
Economic-Tech Frame	+0.115	+0.485	+0.405
Standard Error	(0.042)	(0.045)	(0.051)
Covariates Included	Yes	Yes	Yes
Observations	2842	2842	2842

Furthermore, the data highlighted significant differences based on baseline political ideology. The socio-scientific framing successfully bridged ideological divides regarding science education, generating high levels of support across the political spectrum when the curriculum was explicitly tied to local community problem-solving rather than abstract global debates. This insight is particularly valuable for educational leaders operating in polarized environments, suggesting that localizing socio-scientific issues within the curriculum can mitigate political resistance and foster broader community consensus.

5.3 Discussion of Mechanisms and Broader Implications

The mechanisms driving these divergent outcomes appear fundamentally rooted in how individuals process the utility of formal education. When science education is framed through a civic lens, it activates an identity-based response mechanism, prompting respondents to view scientific knowledge not merely as a compilation of facts, but as a critical tool for community stewardship. The survey experiment provides clear evidence that language and framing within curriculum policy documents are not neutral; they are active agents in defining the purpose of schooling. The broader implications of these findings for secondary education systems are profound. If democratic societies are to successfully navigate an era defined by rapid technological disruption and ecological vulnerability, the educational infrastructure must deliberately cultivate scientific-civic literacy. Policymakers can no longer rely on traditional, siloed approaches to science education. Curriculum documents must be explicitly engineered to emphasize the civic applications of scientific inquiry. By reforming policy language to highlight socio-scientific integration, educational systems can better equip the next generation with the comprehensive literacy required to sustain democratic institutions and implement evidence-based public policies in the face of escalating global complexities.

6. Conclusion and Limitations

6.1 Summary of Findings

This research undertook a comprehensive investigation into the mechanisms through which science curriculum policy framing influences civic literacy and educational policy support. Utilizing a highly controlled, large-scale survey experiment, the study systematically evaluated the differential impacts of generic, socio-scientific, and economic-technological curriculum frames. The empirical findings robustly support the hypothesis that integrating civic responsibility into science education policy significantly elevates the perceived civic literacy and democratic efficacy of stakeholders. Specifically, the socio-scientific treatment not only produced the highest gains in the composite Civic Literacy Index but also generated the strongest public willingness to commit tangible municipal resources to the

curriculum's implementation. The discovery of heterogeneous effects further demonstrated that while younger populations strongly favor civic-oriented science education, older demographics lean toward economic rationales, though localized framing can bridge these divides. Ultimately, the evidence demonstrates that the rhetorical construction of curriculum policy is a powerful lever for democratic socialization, possessing the capacity to shape public attitudes toward the intersection of scientific knowledge and societal governance.

6.2 Limitations and Avenues for Future Research

Despite the rigorous methodological design, this study is subject to several limitations that warrant acknowledgment and provide pathways for subsequent research. Primarily, while the survey experiment excels at isolating causal mechanisms regarding policy framing, it inherently measures stated preferences and intended behaviors rather than actual civic actions or long-term educational outcomes [21]. The immediate cognitive responses captured in a survey environment may not perfectly translate into sustained civic engagement over a student's lifetime. Additionally, the hypothetical nature of the vignettes, though designed for maximum realism, cannot fully replicate the complex, messy reality of curriculum implementation in physical classrooms governed by diverse administrative cultures. Future research must seek to bridge this gap by conducting longitudinal field experiments that track student civic outcomes following the actual adoption of socio-scientifically framed curricula. Moreover, subsequent studies should explore cross-national comparisons to determine how different cultural contexts and baseline levels of institutional trust mediate the efficacy of curriculum framing. Expanding this line of inquiry will further refine educational policies, ensuring they are optimally calibrated to foster the deep civic literacy required for resilient and scientifically informed democratic societies.

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