

**Effects of Discourse, Experience, and Context on Student Choice of STEM Majors in
Higher Education**

Nathanial Hilliard

Purdue University

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Abstract

Increased reliance on the products of STEM fields creates a growing need for STEM professionals and students interested in STEM careers. Research focuses on ways to improve student interest and pursuit of STEM careers. Recent work also examines how student decisions to pursue STEM are made and influenced. Selection of STEM as a college major relies on both internal and external influences, many beyond student control. The decision-making process requires negotiations between the often-conflicting beliefs and needs of students and society. Students' lived experiences impact how such information is interpreted and acted upon. Engagement experiences to foster student interest in STEM may relay realities incongruent with their inherent interests and impact long-term career decisions. Decisions are achieved by balancing values with knowledge, but the values and knowledge students' use are largely derived through their discourses with others. Others may impact student decisions to overcome established obstacles to STEM, but they may also bear less student-centric objectives. Decisions of higher education path are not without consequence, and ill-made decisions may incur costs. Students may not recognize the influences at play but should be wary of efforts made to impact decisions to major in STEM fields.

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Many common conveniences such as mobile phones, GPS navigation, automobile safety systems, DNA screening, and countless others are possible courtesy of growth and innovation within the science, technology, engineering, and math (STEM) fields. Continued growth of STEM however requires increasing the number of college students interested in pursuing STEM careers. Research exists on factors that influence positive STEM outlooks and increase intentions toward pursuit of STEM in higher education, but such efforts are not without potential concern. Efforts to influence student choice in favor of STEM may negatively impact students' ability to freely choose alternatives that may be more appropriate for an individual's needs. Attempts to supplant rather than supplement inherent student interests may lead to decisions based upon others' interpretation of needs rather than the student's actual needs, and thus lead to ill-formed decisions when making higher education choices. This review examines literature on student choice of STEM fields in higher education, how choices are made, how STEM oriented choices are enabled, and how preferentially supporting STEM-based decisions may create conflict with students' processes of forming personal choice narratives. This is considered through a post-structural lens where engaging students to support STEM results from ongoing discourses and preferential interpretation through the contexts of student experience.

STEM Choice

Industry and political leaders continue to express concern over the anticipated shortages of qualified professionals entering the STEM fields, including issues of inadequate diversity and societal representation among graduating professionals (European-Commission, 2004; National Science Foundation, 2005; President's Council of Advisors on Science and Technology, 2010;

Royal Academy of Engineering, 2012). Research examining STEM interest and engagement in pre-university students is available, with studies frequently focused on pertinent issues such as gender accessibility and cultural acceptance of work in STEM fields. Specific characteristics or experiences that impact STEM interest were described. For example Bøe (2012) examined differences in math/science interests among pre-college students, emphasizing the difficulties associated with maintaining girls' science interests. Girls tended to value the utility of science courses toward college admission more than personal interest in science, which may be less than that in other areas, leading to engagement issues during college. Despite what may contribute to girls' interest in STEM, Holmegaard (2015) added the negotiation of cultural expectations to STEM pursuit, further complicating decisions. Similarly, Stiles-Clarke and MacLeod (2017) showed feelings of competence and especially recognition by faculty contributed to pursuit of college physics majors. Students appeared to benefit most when faculty specifically demonstrated the value of physics degrees to students, promoting their formation of positive physics identities during K-12 programs. Rowan and Lynch (2011) also identified faculty interventions that help students overcome stereotypes and identify positive role models as helpful in forming students' own identities in information technology programs.

In conjunction with explicit interest, exposure to STEM related curricula also supported student choice of STEM majors. Wang (2013) indicated that while performance in math/science weighed toward students' intent to pursue STEM majors, the simple exposure of students to K-12 math/science courses best predicted STEM selection in higher education. Bottia et al. (2015) extended this to include in-school and out-of-school STEM experiences that served to inspire or improve student proficiency. Participating students exhibited increased declarations of STEM college majors.

A Post-Structural Approach

Recent works focus less on what actions may improve STEM engagement in favor of examining how and why students form relationships with STEM as a potential career field. For example, while examining the role of gender in relation to STEM pursuits, Godec (2018) exposed various strategies girls utilized to enhance their perceived science identities. Many of these strategies however merely reframed science into more gender appropriate terms, making it more accessible, but still allowing gender disparity to dominate in traditionally masculine areas (e.g., the hard sciences). Similarly, successful creation of a personal identity in STEM may not equate to acceptance within STEM. Individual identities inside and outside of STEM were often viewed as incongruous, perpetuating feelings of exclusion (Pechtelidis et al., 2015).

The identities students form continually evolve and STEM identities may not persist when subject to external influence. Vincent-Ruz and Schunn (2019) described the combination of STEM identities with other non-STEM identities and their fluctuation over time. STEM identities vary, influenced through cultural expectations and competing social identities. Combinations of STEM/non-STEM identities helped to form a balance and contribute to student interest and engagement in STEM.

A key contributor to STEM choice in higher education, as suggested by Wang (2013), is the development of the intent to pursue STEM during the preceding years, however a number of other factors may impact this. Vincent-Ruz and Schunn (2019) suggested that students' STEM identities are malleable, subject to modification through experience. Similarly, Holmegaard (2015) found that despite expectations of student control in choosing a higher education career field, in reality issues of social acceptance, family support, economics, and cultural expectation all contributed to students identity formation. External pressures to conform to the expectations

of others when adopting a STEM identity significantly redefined how these choices were made. Godec (2018) added that while individuals may overcome the role restrictions assigned to STEM fields by the stereotypes of others, they are still subject to social acceptance of their decisions, which may limit the realization of their personal science identities. Similarly, Rowan and Lynch (2011) examined social biases impacting STEM choice and the hidden tensions between acceptance and consequences associated with student selection of STEM. Students' interpretations of their STEM identities tended to conform with social expectations more frequently than social expectations evolved to accommodate students' developing STEM identities. Overall, making the choice of an academic pursuit for higher education is far from under student control alone (Holmegaard, 2015).

Why a Post-Structural Lens?

Post-structuralism aids in the exploration of student generated narratives and shared discourses about the individual processes of identity formation. Researchers may gain additional insight into how major choices are realized through examination the individual truths of each student (Landry & MacLean, 1996). Since choice is derived through multiple, often conflicting influences, its realization requires “embrac[ing] the wisdom of a multiplicity of positions acknowledging the contradictions implicit in them and accommodating ambiguity” (Hutchinson & Wilson, 1994, p. 302).

As alluded to in the hidden tensions described by Rowan and Lynch (2011), individuals have difficulty reflecting accurately on their own experiences and decisions. Limitations in memory, knowledge, understanding, interpretations, and communication all complicate evaluation of lived experiences and how they may contribute to a future self (Wamsted, 2012). Attempts by others to examine the experiences of individuals are similarly frustrated (Wamsted,

2018). External evaluation of students' lived experiences is limited to an evaluation of their ongoing narratives and discourses. The abundance of ambiguity, multiple viewpoints, and variable contexts (Popoviciu et al., 2006) that complicate others' interpretations also suggests how susceptible students may be to such influences.

As students struggle to find a place in their academic future where they can identify with their field, achieve a sense of belonging, and gain social acceptance they must examine their life experiences thus far, both as they see them and as seen by others. In doing, they engage in various forms of discourse to negotiate these alternate views and question the validity of their associated meanings in an attempt to discover the true nature of themselves (Mann, 1994; Slembrouck, 2004). Foucault (1972), defines discourse as a differentiated set of statements delivered through language. It essentially provides a mechanism to transfer consolidated packets of meaning, comprised of discursive statements. Discourse is commonly considered as an oral act, but Foucault's work focused on written statements, and in reality any oral, written, or symbolic/iconic depiction may qualify as discursive statements (Blair, 1987). Within a discourse, discursive statements are organized to represent various concepts and ideas (Pentzold & Seidenglanz, 2006). Knowledge (and its associated power) becomes attached to statements as they interrelate and build upon other statements (Blair, 1987). Discourse then is a complex interworking and exchange of concepts and ideas between individuals, institutions, and environments, each impacting the other to some degree. The collective meaning derived from these discourses is socially constructed between each party and heavily influenced through the context in which it was delivered (Olsson, 2007).

When considering the choices students make to select STEM related majors in higher education, a post-structural approach, which examines the intra and interpersonal discourses of

students, affords researchers a glimpse into how such decisions are simultaneously individual and socially negotiated resolutions of potentially ambiguous and conflicting ideas. These same affordances also suggest means by which student choices may be influenced to enhance selection of STEM majors. In many of the studies described earlier (e.g., Bøe, 2012; Godec, 2018; Pechtelidis et al., 2015; Rowan & Lynch, 2011) there are legitimate obstacles inhibiting students' individual freedom of choice regarding STEM pursuit in higher education. Efforts to improve STEM engagement, interest, and identity to overcome obstacles and increase students' equity of choice may constitute an appropriate use of such influence. Problems may arise however if this influence extends beyond the compensatory and acts to dissuade students from legitimate STEM alternatives.

As Holmegaard (2015) described, students may exhibit varying degrees of interest in STEM subjects, but this interest does not necessarily correlate with an interest to pursue STEM as a career. If students who are persuaded to choose STEM as a higher education path later realize that this conflicts with their long-term career interests, they must consider the future of their academic path. Continuing into an uncertain career choice may or may not work to students' favor, however changing out of STEM into another field (or exiting college entirely) comes with costs. Foraker (2012) examines the effects of changing majors, especially after the introductory years of college, and highlights the potential negative impacts on student grades and graduation rates as well as the likelihood of prolonged enrollment prior to graduation. Sullivan (2010) further discusses the financial impacts on students associated with extending undergraduate enrollment.

The following examines how discourse, experience, and context, issues key to clear interpretation of meaning (Olsson, 2007) come to affect how student choices are made and how

students may experience more than warranted influence toward selection of STEM majors in higher education.

Discourse and Language

Discourse is the primary means by which students may negotiate the meaning and value of differing ideas between themselves and others (Mann, 1994; Slembrouck, 2004). The collections of and relationships between discursive statements (i.e., various ideas or meanings) comprise the limits or scope of discourses (Hall, 2001). Language facilitates the assembly of statements (Graham, 2005) and is vital to the conceptualization and intra/intercommunication of perceptions and experience (Trifonas, 2009). This transfer of information is not exact however. Bakhtin (1981) suggests all language and all speakers are infused with their own particular values, permeating even the most basic of statements, thus there is always something gained or lost in the process of transfer.

Experience through Action as Text

Experience plays an important role in choice and student decisions toward STEM majors (e.g., see Bøe, 2012; Bottia et al., 2015; Vincent-Ruz & Schunn, 2019). Engagement in action often lies at the center of one's experience. Indeed, the performance of actions actually precedes any significant transfer of information, to others or to oneself, about the experience itself (Scott-Baumann, 2011). In science discourses in particular, students' everyday experiences serve to support their own ideas, catalyze change in their own and others' ideas, and promote change in their and their peers' conceptions of science (Na & Song, 2014).

While everyday life provides an abundance of experience, actions may become meaningful when they come to represent something important in an individual's life; that is when the significance of the action extends beyond its initial occurrence (Ricoeur, 1971). Such

meaningful actions may be self-initiated or orchestrated by others, but either way the meaning must be interpreted from the experience. As with any sign or symbol meant to transfer ideas or information within a discourse, actions and experience may be considered as a form of text (Scott-Baumann, 2011), where text here implies the statements of a discourse that must be analyzed from the point of view of the reader (i.e., recipient of the action) (Foucault, 1972).

Discursive statements through actions (action-events) bear similarity to acts of oral discourse (speech acts): Both are experienced by a target, both are ephemeral constructions, and both relay some form of meaning to the individual (Ricoeur, 1971). Thus, as with any written or spoken discursive statement, there may be disagreement between the motivation and intent of the authors of actions and the interpreted understanding of the recipients (Scott-Baumann, 2011). Ricoeur (1976) further suggests that direct transfer of an experience from author to recipient is not possible without an intervening alteration of the intended meaning, influenced by the lived-experiences and interpretations of the target. While experience through action may be planned as part of a discourse, possibly in conjunction with other types of statements, the message delivered is subject to reinterpretation through the available contexts of the recipient's lived experiences.

Context

Since the context available to recipients is highly relevant to how they may interpret any particular discursive formation, authors of discourse may consider and make efforts to supplement the contexts made available through an individual's lived experiences in an attempt to improve the fidelity of their intended message (Shen, 2013). A primary purpose of messaging through discourse is to exert influence, sway others in the world, and enact change (Clarke, 2015). Post-structuralism supports the concept that ideas represented through discourse need not be grounded in reality if they are supported by other powerful, well-formed discourses. Indeed,

misrepresentations of reality may result as byproducts of other well-established, accepted discourses (e.g., an over-realization of behavioral problems in children stemming from an established discourse describing the ideal child) (Lanas & Brunila, 2019). Discourse constructs rather than represents reality (Pinar et al., 1995). Its goal is to evoke action more than to simply inform (Clarke, 2015).

To achieve the desired communicative goals, access to relevant context is a necessity. As Derrida (1944) stated, “there is nothing out-of-context” (p. 158); interpretations are individualized, built from one’s own experiences. There is no inherent meaning outside the context used for interpretation. Shen (2013) adds that since individuals exhibit such variety in their lives and their experiences, they may draw from any number contextual references when attempting to interpret discourse; to achieve the desired interpretation, an appropriate context must be available. This need not be the only available context and certainly, alternate contexts may yield very different interpretations. Shen relates this to the principle of relevance: When multiple contexts are available that would yield differing interpretations of a given discursive statement, the most likely result is the first to have sufficient contextual backing. Essentially, the recipient of discourse will expend the least effort possible to make adequate sense of what was just experienced.

This point is critical for those who desire to communicate a precise message through discourse. While an individual may have a multitude of experiential contexts from which to draw, contexts recently constructed through carefully coordinated discursive exchanges that adequately support the original intent are the most likely to support that interpretation. This application and manipulation of context to influence discourse interpretation parallels the use of language to organize and deliver discursive statements intended to convey specific meanings.

Effects on Student Choice

The process of choice, particularly with students selecting their academic fields and potential future careers, is complicated and interconnected without clear correct solutions. Paul (1986) suggests that choice is a messy problem, one that requires evaluation of a multitude of experiences and competing perspectives, all interpreted through the individual contexts available to the students (Reznitskaya & Sternberg, 2012). This contextual interpretation of experiences mirrors that required by discourse.

Choice of academic path for students involves not only personal negotiation of interests and identity but also integration of influences and expectations from external direct pressures of social or cultural standing (Godec, 2018; Holmegaard, 2015) and indirect pressures of political or institutional workforce development concerns (European-Commission, 2004; President's Council of Advisors on Science and Technology, 2010). These indirect pressures may also permeate downward through academia to school administrators, teachers, and parents who present further influence and prescribed guidance to students engaged in career making decisions. Students are then left to balance their decisions amongst the prevalent internal and external influences, considering what values those may represent. Reznitskaya and Sternberg (2012) however question how such values are determined and who decides which values are more "right" than others, and thus should weigh more heavily in decisions.

Wise students, as suggested by Reznitskaya and Sternberg (2012), will primarily base decisions upon a union of their own values and knowledge along with consideration of external inputs and pressures over the short and long term. Student knowledge and values are, to a large degree, developed through the discourses encountered throughout their academic careers. As suggested by Clarke (2015) and Lanas and Brunila (2019), discourse may serve more to exert

influence than convey factual information, constructing a perceived reality that does not exist outside of the discourse. Under these circumstances, the origin of the values and knowledge contributing to the decisions students make about their academic careers is at question.

Throughout primary and secondary education, ample opportunities exist to establish supportive and perpetuating discourses involving action as experience. If student STEM experiences include meaningful actions, such as those promoting a sense of identity, belonging, or purpose, those experiences may be interpreted by students as part of an ongoing discourse that was designed to convey a specific sense of their STEM reality. As students undoubtedly exhibit a diverse array of lived experiences, the contexts used for interpretation may vary significantly. Appropriate contexts for the discourse author's desired intent could be embedded directly into the experiences or built up over time through student interaction with previous discourses.

A simple example may be extended from Godec (2018) who examines how girls who may or may not exhibit an interest in STEM must cope with both personal and social expectations when developing a gender related identity compatible with a career in a STEM field. Individual acceptance of a STEM identity is itself inadequate as the identity must also meet the gender expectations of her existing social networks. Given an experiential engagement activity designed to promote interest and identification with STEM as a viable career path, success requires the female student to have a referenceable personal context allowing the desired interpretation of "I feel as I can do, I can be successful at, and I can be accepted in a STEM career". If relevancy theory is considered (Shen, 2013), the context would need to be readily accessible and able to outcompete any preexisting contexts that may not support the desired interpretation. A direct approach to ensuring the appropriate context would be to embed the gender roles which would best fulfil the expectations of her particular social networks (e.g.,

focusing on race, culture, social, education, or other particulars as appropriate for the audience). In this way, an appropriate context sufficiently supporting the intent of the authors of the STEM experience is immediately apparent and accessible to the student, and available to outcompete alternative contexts which may already exist based on the student's life experiences.

A process such as this may work to serve the original intent of the authors of the experience, which is to increase a female student's ability to identify with STEM careers and increase her likelihood of pursuing STEM in higher education. In cases of compensating for legitimate obstacles to STEM pursuit due to conflicting personal and social expectations and acceptances, this process may be acceptable and serve a greater good for both the student and society. Alternatively, this may also work to offset legitimate disparity between a student's interest in pursuing STEM and society's need for students to pursue STEM. Holmegaard (2015) and Vincent-Ruz and Schunn (2019) describe how competing or alternative interests may either work together or compete against each other in regard to STEM interest. Holmegaard further showed how such interests competed equally with STEM in relation to the choice of majoring in STEM in higher education. Thus, while STEM identity may be enhanced through the perceived reality a discourse of active engagement creates, enticing students to pursue STEM in higher education may fulfill the biased needs of society over the individual needs of the students. Such biases ultimately may not be visible to students, however. Realization of how language and discourse may represent differing motivations and how this may bias student decisions develops only over time and with exposure to multiple versions of similar experiences, authored with differing intentions (Case, 2005).

Conclusion

The increasing demand for STEM graduates by expanding STEM related career fields is a concern for current educators and educational institutions. Promotion of STEM as a viable career is both valuable and necessary to overcome persistent biases and inequities in both in academia and industry. Care is warranted, however. Concerted efforts to combat inadequate numbers of STEM graduates with purely increased throughput achieved by way of ubiquitous engagement programs may not be the best solution. Increased enrollment into STEM is an excellent goal for students truly interested, motivated, and contented with the career path STEM may offer. The use of discourse, action as experience, and context as a gentle manipulator to offset oppression, discrimination, and exclusion of students who would truly enjoy and thrive in STEM is a worthy goal. The use of discourse and context manipulation to ensure success of engagement programs through sweeping increases in STEM enrollment at the risk of actively inhibiting legitimate competing interests and student autonomy is not. When discourse intends to shape perceived reality, to exert power over others (Pinar et al., 1995), its motives must be questioned. When applying such discursive influence over students to fulfil external agendas, academic institutions flirt with misappropriation of their power, a potential warned of by Foucault (as cited in Besley, 2015). One should be particularly wary and critical when educational discourse is enacted to achieve particular goals in the name of serving a greater good (Besley, 2015).

Limitations

Existing research does not significantly address the subject of this review. Consequentially, a variety of references were drawn from the core topic areas and unified to illustrate the issue of student choice of STEM majors in higher education. Little of the available

research is tightly focused on STEM as it treats its specific topics. Additionally, the intended goal of any given experiential activities (e.g., STEM engagement) may be unknown. They may strive to overcome obstacles and improve equity and access to students or, they may attempt to bolster STEM program enrollment to meet specific institutional goals. The described studies also provide limited insight into the impact such engagement makes on students, whether choosing to pursue STEM or another field. Finally, much this work draws on theoretical discussions around the interpretation of discourse with the addition of limited STEM related research. Further work focused on STEM is needed in support of the key points of engagement experience designs, student interpretation of engagement, and attrition due to alternative interests.

Future Research

STEM choice is a composite of prior experiences, social negotiations, and future expectations. Additional longitudinal work is needed to investigate how student choices resolve over time, what impacts those choices have on perceived career satisfaction, and how professionals perceive the success of their choices made as students. Also, when considering students involved in STEM programs or engagement, how did their alternative interests contribute to their decisions? Many of the studies presented here focused primarily on students who exhibited an interest in pursuing STEM. Additional exploration of students who did not overtly exhibit STEM interest yet still chose to pursue STEM would add to the understanding. Finally, despite specific discussion of experience as an influence in STEM decision making, more work is needed on the explicit design of STEM outreach activities to identify what elements are included and how they work to influence student choice of STEM majors in higher education.

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