INFLUENCE OF AUTONOMY, SCAFFOLDING, AND AUDIENCE ON ENGAGEMENT IN STUDENT-CENTERED LEARNING ENVIRONMENTS

by

EUNBAE LEE

(Under the Direction of MICHAEL J. HANNAFIN)

ABSTRACT

Student-centered learning environments (SCLEs) provide contexts in which students assume increased autonomy and responsibility for their own learning. Students set learning goals; choose their paths to achieve the goals; explore, evaluate, and select resources; think critically to make further decisions based on emerging understanding; and design, develop, and share artifacts to represent their learning. The skills and knowledge students develop through student-centered learning suggest alternatives to preparing today's students for tomorrow's unknown challenges. Despite considerable prior research, many educators and designers lack a theoretically grounded framework to engage students in student-centered learning.

This manuscript style dissertation presents the products of a design-based research program of inquiry to design, evaluate, and suggest a comprehensive framework for college-level student-centered learning environments. The theoretical framework was grounded in Constructivist and Constructionist epistemologies and Self-Determination theory. The Own it, Learn it, and Share it (OLSi) framework was informed by prior and current research evidence, and tested and refined iteratively during ongoing collaboration with the course professor in the spirit of design-based research.

This dissertation document comprises an introductory chapter (Chapter 1) and a conclusion chapter (Chapter 6) that frame four journal-style manuscripts: Chapter 2 presents OLSi's theoretical framework related to autonomy support, scaffolding, and audience. Chapter 3 reports findings from a needs assessment conducted prior to the full implementation of OLSi. Students' experience while engaging a student-centered narrative writing assignment was examined through the collaboration between the researcher and the science educator. Chapter 4 presents a detailed analysis of the implementation of OLSi in a postsecondary student-centered science learning environment, including pre-and post-surveys featuring self-determination questionnaires, in-depth analyses of student interviews, observation, and course documents on the influence of autonomous motivation, scaffolding, and audience on student engagement, performance, and improvement. Finally, Chapter 5 presents practitioner-oriented guidelines for supporting autonomy in higher education, online contexts.

INDEX WORDS: Learning design, engagement, student-centered learning environments, constructivist learning, science education, educational design research

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DEDICATION

This dissertation is warmly dedicated to my parents, Inhee Lee and Inock Kim; my parents-in-law, Dongchul Park and Hyunwha Jin; my husband, Saeyeul Park; and my son, Quha. Your unfailing love and support broadened, deepened, and strengthened my perspectives as a lifelong learner.

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Thinking of my family, I do not know where to begin. I have been living abroad, away from my family for over a decade now. My parents, Inhee Lee and Inock Kim, have given me so much of their lives. Without their sacrifice and immense love, I would not have been able to begin, let alone, complete my journey. While I was growing up, my parents told me to do my best rather than to be the best. They are the origin of my belief in empowering people to become the owners of their learning.

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CHAPTER 1

INTRODUCTION

Student-centered learning environments (SCLEs) provide contexts in which students become owners of their learning (Hannafin, Hill, Land, & Lee, 2014). Students assume increased autonomy and accountability for decisions they make and actions they take. Students set learning goals; choose their paths to achieve the goals; explore, evaluate, and select resources; think critically to make further decisions based on emerging understanding; and design, develop, and share artifacts to represent their learning. Students critically evaluate existing resources to make meaning through uncertainty (Bransford, Brown, & Cocking, 2000). This process requires students to play diverse roles as critical thinkers, decision makers, problem solvers, and creative producers.

While SCLEs are potentially relevant in any educational settings, the need is especially pressing in higher education. Increasing numbers of high school graduates attend college. Enrollment rates of 18- to 24-year-olds in the U.S. degree-granting 2 or 4 year higher education institutions was reported to be 42% in 2011 (U.S. Department of Education, 2013). Increasing postsecondary enrollment indicates a growing need among college graduates in the society. A key role for higher education is to prepare today's students for tomorrow's workforce. Society values workforces that meet current needs while addressing an unknown future. The skills and knowledge students develop through student-centered learning suggest alternatives to preparing today's students for tomorrow's unknown challenges.

Whereas educators and designers have employed SCLEs, there are often disconnections between and among theory, research, and practice resulting in counterproductive student learning (Hanrahan, 1998). Grounded design practices for any learning environments should align epistemology, theory, research and practice with learning goals (Hannafin & Hannafin, Land, & Oliver, 1997). Dewey (1916) asserts that the ability to direct one's individual course of action increases the meaningfulness of the learning experience. Constructivist researchers have identified roles and expectations for both teachers and students to facilitate student-centered learning (Jonassen, 1991, 1999; Hannafin, & Land, 1997; Hmelo-Silver, Duncan, & Chinn, 2007; Lea, Stephenson, & Troy, 2003; Schmidt, Loyens, Van Gog, & Paas, 2007). Complementary interactions between and among motivation and SCLEs have been discussed (Baeten, Dochy, & Struyven, 2013).

Despite considerable prior research, many educators and designers lack a theoretically grounded framework to facilitate SCLEs. Successful SCLEs require student engagement in the process from building ownership, to executing independent inquiry and creating artifacts of understanding. This dissertation represents a program of inquiry to design, evaluate, and suggest a comprehensive framework that is grounded in theory and research and aligned with the learning goals of SCLEs. In the spirit of design-based research, this dissertation connects theory and real world classroom research to yield a design framework that invites further critique, evaluation and refinement (Wang & Hannafin, 2005).

Dissertation Overview

This dissertation is a compilation of four manuscripts designed to further understanding of systemic approaches to engaging students in SCLEs in higher education. The first article focuses on a conceptual framework and review of the literature on autonomy support, scaffolding, and audience informed by Self-Determination Theory, Constructivist theory, and Constructionist theory, respectively. We suggest design guidelines for enhancing engagement under the framework of the Own it, Learn it, and Share it (OLSi). OLSi provided the theoretical grounding for subsequent methodology as well as the implementation of student-centered science learning throughout the dissertation research.

The second article reports a needs assessment study conducted prior to the full implementation of OLSi. Students' experience while engaging a non-traditional, student-centered narrative writing assignment was examined. The needs assessment indicated two major issues that became the foci of a subsequent study. First, the students' achievement deviated from the course instructional goal. The students' interpretation and objectives of the narrative writing assignment were idiosyncratic. In addition, the students' level of engagement with the assignment varied. We present a science educator's perspectives to promote SCLEs.

The third article is a detailed analysis of the implementation of OLSi in a postsecondary student-centered science learning environment. Pre-and post-surveys of the self-determination questionnaires and in-depth analyses of student interviews, observation, and course documents yield rich data on the influence of autonomous motivation, scaffolding, and audience on student engagement, performance, and improvement.

Finally, the fourth article presents practitioner-oriented guidelines for supporting autonomy in higher education online learning contexts. Successful completion of online learning requires autonomous motivation to self-regulate cognitive, behavioral, and affective engagement in learning activities performed via distance. Theory, research evidence, design propositions, and exemplary assignment descriptions are accompanied to provide practical guidance for instructors and designers of online learning.

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CHAPTER 2

LITERATURE REVIEW

ENHANCING ENGAGEMENT IN STUDENT-CENTERED LEARNING ENVIRONMENTS[1]

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[1] Lee, E., & Hannafin, M. J. To be submitted to *Educational Technology Research and Development.*

Abstract

Educators and designers of student-centered learning environments (SCLEs) require clear guidelines to support students' engagement and autonomous learning. We present an empirically- and theoretically-grounded framework to support student-centered learning. A synthesis of self-determination theory as well as constructivist- and constructionist-inspired epistemologies has been integrated to inform the framework. This framework suggests that students: (a) internalize the learning goal; (b) learn autonomously through metacognitive, procedural, conceptual, and strategic scaffolding; and (c) generate an artifact that is aimed at real world audiences. We examine the implications of theory and research-based evidence to inform practitioners as well as researchers of SCLEs.

Keywords: engagement, student-centered learning, constructivism, constructionism, self-determination theory

Introduction

Contemporary society requires its members to meet emerging challenges and needs to adapt and support needed transformation. In the industrial age, the factory model of instruction proved essential and satisfactory in meeting societal needs. Behaviorist and cognitivist-inspired approaches were adopted to replicate responses and performance across diverse education and workforce populations.

In the 21st century, however, the information society demands different skills and abilities from its students and citizens. We now expect the workforce to demonstrate key adaptive skills needed to think critically, make decisions, solve unanticipated problems, and work collaboratively to address emergent and often unexpected shifts in priorities. We cannot be certain as to precisely which challenges will emerge and under what circumstances the workforce will need to adapt. It is therefore critical that formal education prepares students to negotiate future uncertainties.

Student-centered learning (SCL) methods have been touted as approaches that can enhance the flexible, adaptive skills essential in the 21st century workforce. In student-centered learning environments (SCLEs), students create a learning opportunity for themselves, assume increased autonomy and responsibility for their learning, and are immersed in the pursuit of knowledge construction (Hannafin, Hill, Land & Lee, 2014). They identify their learning goals; create a path to achieve the goals; explore, select, and use tools and resources; monitor their progress; communicate and collaborate with others; and finally, generate and test possible solutions, skills designed to prepare students for ill-defined situations during their lifetimes.

Student-Centered Learning: A Primer

While applicable across all education levels, SCL may be particularly important during college where the implications for a student's career potential are more imminent. Prior to college, traditional curriculum and teaching methods have been characterized as emphasizing "compliant understanding" (McCaslin & Good, 1992), expecting and receiving explicit direction from instructors, and subsequently being assessed for concordance with external expectations. Student engagement is characterized as passive, and focuses on specific test outcomes rather than individual understanding or independent learning (Maclellan & Soden, 2003). Nonetheless, current higher education does little to prepare students for uncertainty of their future environments.

SCLEs highlight the importance of *learning environments* over traditional teaching. Table 2.1 compares traditional direct instruction with student-centered learning approaches. Generally, learning environments may focus on student knowledge acquisition, the individual's reasoning and understanding of key concepts, or different foci combinations.

Table 2.1. *Comparisons Between Directed Instruction and Student-Centered Learning*

	Directed Instructional Environments	Student-Centered Learning Environments
Theoretical Framework	Objectivism	Constructivism
Nature of Learning	Students process specified content	Students construct knowledge by exploring and analyzing
Methods	Directed learning	Open learning
Content	Well-defined	Ill-defined
Learning Goals	Defined by curriculum or teacher	Negotiated by students
Student's Roles	Knowledge receiver	Knowledge generator and evaluator
Teacher's Roles	Knowledge transmitter	Facilitator, scaffolding provider
Locus of control	External	Internal

Adapted from Jonassen (1991)

As contrasted in Table 1, SCLEs are neither rigidly prescribed nor structured. The importance of understanding and reasoning resides within individual students who may address externally- required learning goals or initiate and pursue their own learning goals. In effect, students determine appropriate means to pursue external as well as individual learning goals, including making decisions about how, when, and whether to proceed based on emergent understanding. They access, evaluate, select, and reason with a myriad of resources as they monitor ongoing understanding, reflect on what they have learned, and where further inquiry is needed for clarification (Hannafin, Hill, Land, & Lee, 2014). In contrast, direct instruction controls and directs instructor's teaching practices (Wilson, 1996). The instructor establishes instructional objectives, selects resources, provides the associated context, organizes the associated content and specifies and assesses canonical understanding based on external requirements.

SCLEs, therefore, reflect a paradigm shift in both students' and instructors' roles during learning, from passive roles of students as information receivers to owners of their goals, decisions, and actions. Students plan and pursue external goals with their individual goals, build on unique background knowledge and experiences, develop personal strategies, formulate questions, make inferences, integrate new knowledge with existing knowledge, and refine and reorganize their thinking (Bransford, Brown, & Cocking, 2000).

Both students and instructors need support to realize these roles. Students may not be prepared to take a more active role and greater autonomy in their learning. Students who are "accustomed to more passive roles in the college lecture hall may initially resist the active requirements of constructivist pedagogy" (Reeves, 2006, p. 304). College students who have benefited from receiving expected outcomes and didactic instruction often experience difficulty when encountering approaches to teaching and learning that assume greater individual mediation (Kember, 2001).

Likewise, instructors may question the value or effectiveness of student-centered pedagogical approaches (Kember, 1997) or lack experience or strategies to engage students in self-directed learning (Blumberg, 2009). Instructors' approaches, in turn, affect students' expectations and approaches to learning as well as learning outcomes (Kember & Grow, 1994) and epistemologies (Sheppard & Gilbert, 1991). Reconciliation of alternative roles is "teachable and learnable," but requires the ability and willingness to identify differences between instructor and student epistemological beliefs about teaching and learning and "willingness to adapt strategies accordingly" (Song, Hannafin, & Hill, 2007, p.35).

In this paper, we examine key constructs underlying the effective implementation of SCLEs: Self-Determination theory, constructivist-inspired support, and constructionist-inspired epistemologies. We present a framework and research-based guidelines to support instructors' and designers' efforts to support students' autonomy, employ scaffolding, address a real world audience, and subsequently enhance students' learning performance.

Student-Centered Learning Environments Framework

Self-determination theory (SDT) provides explanations about how autonomy plays a key role as a motivational factor in SCLEs. Constructivism offers an underpinning epistemology about how learners negotiate their learning to construct meaning, particularly with regard to the role of scaffolding to facilitate learning. Constructionism offers a guiding theory of SCLEs where students learn from the complex, dynamic process of designing and developing an artifact and sharing the artifact with a real world audience. In the following section, we describe their underlying epistemologies and associated assumptions as well as their implications for autonomy, scaffolding, and real world audiences in the design of SCLEs.

Self-Determination Theory

SDT motivation theory provides a key frame to understanding the influence of autonomy during learning. According to SDT, behaviors vary in relation to the degree to which they are mediated autonomously versus externally. Motivation ranges from controlled, extrinsic motivation through increasingly autonomous level to intrinsic motivation (Ryan & Deci, 2000). Ryan and Deci further note that intrinsic motivation, the most autonomous form, is directly associated with individual satisfaction and autonomy. According to Deci and Ryan (2000), autonomous behaviors emanate from one's integrated sense of self, are experienced as volitional, and reflect interest or personal importance.

Ryan and Deci (2000) argued that intrinsically motivated individuals strive to extend their ability and enjoy doing the activity itself. Intrinsically motivated activities include those that individuals find interesting and would pursue even in the absence of externally imposed pressure (Ryan & Deci, 2000). When intrinsically motivated, students tend to set goals to understand a task, acquire new knowledge, and develop their abilities. Intrinsically motivated, autonomous behaviors help to engage students in deep, individual, meaningful processing. Students who pursue intrinsic goals tend to engage their learning tasks more actively than those who pursue primarily external affirmation, recognition by instructors, or avoidance of negative consequences (Meece, Blumenfeld, & Hoyle, 1988). Acee et al. (2012) reported that autonomously established goals tended to yield positive effects on college students' academic performance.

In contrast, directed pedagogies are extrinsically motivated. When extrinsically motivated, individuals act in accordance with external requirements rather than the individual's perceived value of learning (Deci & Ryan, 2000). Extrinsically-motivated performance goals emphasize demonstrated competence in defined outcomes. External forces may confound relationships between individual student needs and their outcomes, particularly when learning tasks involve flexible, heuristic, creative, or autonomous motivation for successful performance (Deci, Koestner, & Ryan, 1999). However, distinctions between autonomous and controlled motivation do not adequately account for the complexities and intricacies of academic motivation (Alexander, 1997). Interactions between autonomous and controlled motivation influence students' learning and performance in SCLEs.

In effect, SDT suggests that individual autonomy enhances volition, motivation, and engagement and enhances performance, persistence, and creativity (Deci & Ryan, 2000). In SCLEs where students solve complex problems that require creativity and flexibility, intrinsic motivation tends to enhance performance more than externally-based performance goals alone. When students make autonomous decisions, they assume greater responsibility for directing their learning, become more personally engaged, and deepen their understanding. Accordingly, SCLEs promote opportunities to cultivate individual responsibility for engaging learning opportunities, which enhances academic performance as well as student autonomy.

Constructivism

Constructivism is not a single, unified theory; rather, constructivism represents an epistemological perspective as to the nature and evolution of individual understanding. Schunk (1991) explains, "constructivism does not propound that learning principles exist and are to be discovered and tested, but rather learners create their own learning" (p. 236). Despite ongoing debates related to ontological assumptions and nomenclature, constructivism provides assumptions underlying student-centered learning (Sharma, Xie, Hsieh, Hsieh, & Yoo, 2008).

Constructivism variants commonly suggest that learner, context, knowledge and understanding are connected and interdependent. Constructivist learning involves iterative processes of discovery as students use their own mind to obtain knowledge for themselves and "rearranging or transforming evidence" to assemble "additional new insights" (Bruner, 1961, p. 22). Individuals do not receive and process information passively, but they actively construct knowledge and skills and reorganize their understanding via interactions with their environment as well as other encounters and past experiences (Jonassen, 1999).

In SCLEs, students are situated in an active, authentic context that facilitates their sense-making process. The instructor's role generally involves not leading students to discover what is "out there" but guiding students to determine individual meaning. To support discovery, students experience diverse models and feedback on their actions, which subsequently promote interaction between the student and others. Students interact reciprocally with peers and more knowledgeable others to support richer understanding than is possible individually (Vygotsky, 1978). Students communicate their ideas and make their thoughts explicit; they examine both their own perceptions and others' views and react accordingly.

Constructionism

Constructionist theory is similar to constructivism in that students actively "construct" rather than simply receive, store, and retrieve knowledge. Bruner's early emphasis on learning by discovery was subsequently refined and extended to learning by negotiating and sharing (Bruner, 1986). Bruner (1986) characterized learning as "a communal activity, a sharing of the culture"

(p. 127). Students individually internalize knowledge within communities that include others who share their sense of belonging to a culture (Bruner, 1986).

However, constructionism also differs from constructivism. Shareable artifacts reflect and embody student learning. Constructionists produce external and shareable artifacts (Harel & Papert, 1991), reflecting the belief that "constructivist processes are more evident when students collaborate to produce and share representations of their understanding of the world" (Jonassen, Myers, & McKillop, 1996, p. 94). Students become designers whose artifacts reflect complex cognitive negotiations with external constraints; in effect, their designed and created products represent socially shared cognitive representations (Jonassen, Myers, & McKillop, 1996). Activities such as making, building, programming, teaching, and consulting provide rich contexts for learning (Harel & Papert, 1991). Failure, reflection, and iterative revisions refine understanding of concepts and associated skills and practices (Kolodner et al., 2003).

Constructionists also note that learning occurs both during the design process as well as through sharing products. Constructionist learning environments create a culture and community as students share one another's creations and gain a deeper understanding of other people's perspectives about the product and ideas related to the product (Evard, 1996). Environments promote learning by doing as well as learning by thinking and discussing what you do (Kafai & Resnick, 1996). Products require students to represent their thinking explicitly. In middle-school science inquiry-based construction activities, students justify their design decisions and explain the mechanics of their products (Kolodner et al., 2003).

Finally, constructionists regard affect as critical for learning, whereas constructivists focus principally on cognitive development (Kafai & Resnick, 1996). Constructionists suggest that students become intellectually engaged when they work on personally meaningful activities and projects and thus become personally invested. This enthusiasm influences both students' attitudes toward the subject matter as well as their performance (Harel & Papert, 1991). Students become cognitively and emotionally engaged as they employ resources in a social context and design and refine both their understanding and artifact. The key is connecting explicitly subject learning and construction activities as students may conceive construction activities as arts and craft activities rather than formal domain learning activities (Hmelo, Holton, & Koldner, 2000).

Thus, constructivist and constructionist theories promote individual autonomy, as students construct personal meaning in student-centered learning environments. Accordingly, a student's responsibility for individual understanding increases as associated ownership of both learning processes and the products increase. In the following section, we discuss how autonomy, scaffolding, and real-world audiences are applied in student-centered learning environments, and present a framework for supporting autonomy, designing scaffolds, and incorporating real-world audiences.

Student-Centered Learning Assumptions

As shown in Figure 2.1, current SCLE theory and research has documented how three key constructs influence students' engagement. Table 2.2 presents a snap shot of the engagement constructs of SCLEs and the supporting literature.

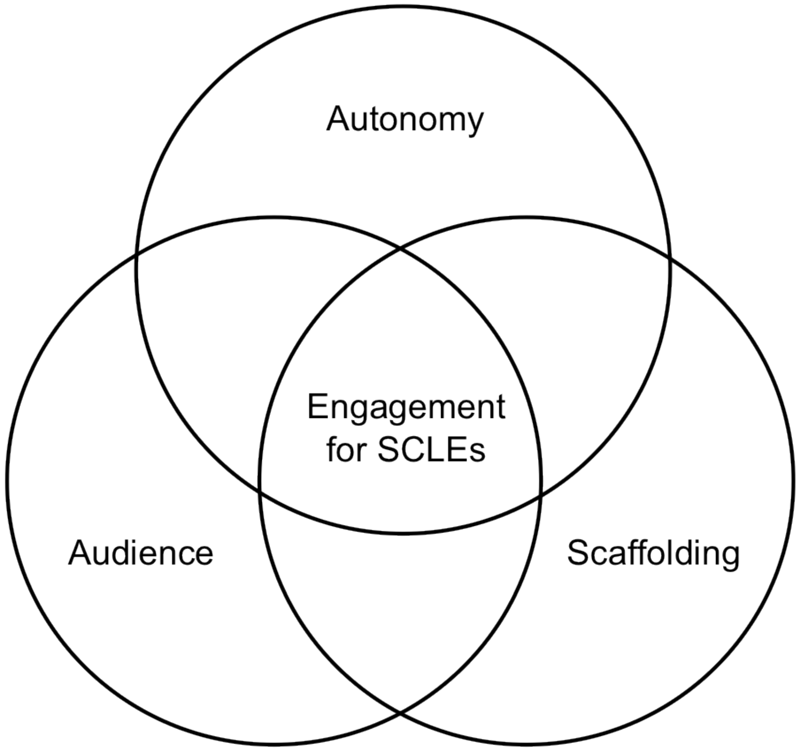

Figure 2.1. Engagement constructs of student-centered learning environment

Table 2.2. Description of Engagement Constructs of Student-Centered Learning

Constructs	Description	Supporting literature
Autonomy	Students have an internal locus of control.	Behaviors emanate from an integrated sense of self, are volitional, and are guided by interest or personal importance (Deci & Ryan, 2000).
	Autonomy influences positively on academic performance.	A mastery goal leads to better performance than having performance goals (Meece, Blumenfeld, & Hoyle, 1988). Autonomous goals yield positive effects on college students' academic performance (Acee et al., 2012). Autonomy fosters a high level of volition, motivation, and engagement and results in enhanced performance, persistence, and creativity (Deci & Ryan, 2002).
	Students can feel autonomous when engaged in imposed activity.	Autonomous behavior is not limited to independent initiatives (Ricoeur, 1966; Dworkin, 1988; Reeve, Jang, Hardre, & Omura, 2002).
	Teachers should support student autonomy.	Teacher's autonomy support is favorably related to students' engagement, concentration, better time management, self-regulation, and higher performance (Jang, Reeve, & Deci, 2010; Reeve, 2006).
	Autonomy support and structure should be provided together.	When combined with structured guidance, autonomy support is effective in fostering students' self-regulation (Reeve et al., 2004; Sierens et al., 2009). Providing both autonomy support and structure yielded positive effects on intrinsic motivation and learning outcomes (van Loon, Ros, & Martens, 2012).
Scaffolding	Multiple measures and guidance should support.	Scaffolding is provided to support procedural, conceptual, metacognitive, and strategic performances separately or combined (Hannafin, Land, & Oliver, 1999).
	Scaffold until students can function without it.	When student demonstrates competence, scaffold is withdrawn to promote independent functioning (Vygotsky, 1978).
	Procedural scaffolds walk through the process.	Eighth grade students were provided detailed instructions on what to do and how to do it for each science problem solving activity (Oliver & Hannafin, 2000; Davis & Linn, 2000).
	Conceptual scaffolding helps determine how new content can be organized.	A study guide and a concept map template scaffolded 5th graders' collection of relevant information and to connect information associated with the WebQuest topic. (MacGregor & Lou, 2005) Students who received knowledge integration scaffolds made intentional efforts to identify concepts and relationships and performed significantly better when developing and justifying solutions and considering alternatives (Chen & Bradshaw, 2007).
	Strategic scaffolds support approaching and resolving challenges and considering	Expert modeling of thinking processes enables novices to embrace alternative strategies (Pedersen & Liu, 2002). Peer interaction during problem solving enables identifying alternative views, building upon others' ideas to develop solutions, considering more information, and offering suggestions and feedback (Ge & Land, 2003).

	multiple perspectives.	Reflections on others' ideas encourage identifying one's own weaknesses and modifying the approach to the activity (Choi et. al., 2005).
	Metacognitive scaffolds guide in goal setting, planning, organizing, self-monitoring, and self-evaluation at various points.	Eighth graders who received conceptual and metacognitive scaffolding wrote better articles and exhibited more task-focused and self-directed behaviors (Wolf, Brush, & Saye, 2000).
		College students received metacognitive prompts via peer feedback monitored learning and adapted strategies and were likely to plan, evaluate, and revise their assignment (Kim & Ryu, 2013).
	Scaffolding can be dynamic or static.	Static scaffolding has proven effective in learning basic information but often ineffective in promoting the reasoning and thinking skills (Kim & Hannafin, 2011).
		College students who received adaptive advice for complex problem solving outperformed those who received advice from the virtual teacher at fixed time intervals (Clarebout & Elen, 2006).
		Students who received dynamic scaffolds demonstrated increased activation of prior knowledge, greater changes in mental models, more frequent and regulated planning and monitoring of progress, and help seeking and effective strategy (Azevedo, 2005).
	Instructors, peers, and technology can offer scaffolds separately or together.	Fourth grade students' peer feedback and social processing through appropriate technology enhance engagement and learning (Roschelle et al., 2010).
		College students using the Web-based formative peer assessment (WFPAS) performed better and displayed higher level of reflection and self-regulatory skills (Kim & Ryu, 2013).
Audience	Students' motivation is enhanced when constructing artifacts for real world audiences.	Seventh-grade students performed better when their paper was intended for peers at distance than for instructors (Cohen & Riel, 1989).
		Native Spanish-speaking students preferred blogging than traditional writing and demonstrated improved fluency and grammatical improvements (Montero-Fleta & Pérez-Sabater, 2010).
		Elementary and secondary students, who produced digital videos and shared with their peers, demonstrated increased autonomy and task ownership (Kearney & Schuck, 2006)

Autonomy

Autonomy is considered an important factor across all facets of human living, including educational settings as well as workplaces, health, sports and leisure. Autonomy fosters affective benefits, such as engagement, satisfaction, happiness, and wellbeing. When individuals perceive autonomy, they believe their action supports their own will, choices, and self-determination (Ryan & Deci, 2006).

Autonomy has been associated with locus of control by personality theorists (e.g., Rotter, 1966). When individuals perceive internal control, they believe they control events that affect their lives; the outcomes of their actions result from their own decisions and abilities. In contrast, when control is perceived as externally regulated, individuals believe they have limited influence on outcomes and their individual decisions and skills: they perceive future success or failure depends on external circumstances beyond their control, such as task- difficulty or luck (Rotter, 1975). Rather than only internal or external perceived control, individuals may perceive combinations of control, referred to as Bi-locals. Bi-locals may take personal responsibility for their actions and the consequences thereof while remaining susceptive to cooperating with external resources (Palenzuela, 1984). The perceived locus of control may well explain different psychological influences of autonomy in educational settings.

Autonomy is important to ensure that students own their learning processes. Students mediate learning processes when they determine and accomplish learning goals; instructors, in effect, support rather than dictate learning responsibility (Dochy, Segers, Van den Bossche, & Gijbels, 2003). By varying the locus of perceived control, students maintain personal responsibility for learning as they utilize external resources. In effect, autonomy becomes salient in motivating individuals to initiate and engage a learning environment (Deci & Ryan, 2000).

Figure 2.2 depicts the role of autonomy in SCLEs. In SCLEs, autonomy supports two roles: sovereignty and responsibility. In terms of sovereignty, students assume the power and control to determine learning goals, decisions, and actions required to achieve those goals. When encouraged to make decisions, students perceive it as taking control of their learning and develop personal ownership. For responsibility, students become accountable for the consequences of their goals, decisions, and actions. They assume responsibility for managing their learning processes and project completion. Increased autonomy is critical to sustain and continue motivation.

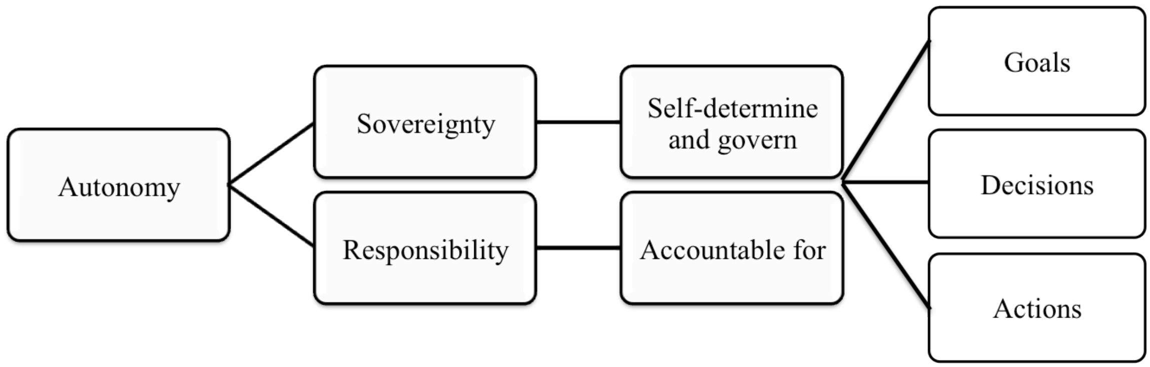

Figure 2.2. Role of Autonomy in Student-Centered Learning (Adapted from Deci & Ryan, 2000)

However, autonomy is not synonymous with independence, but rather involves how self-determination reflects one’s will. Autonomy is not limited to independent initiatives, but also applies to actions evoked voluntarily to address external acts, rules, and pressures (Ricoeur, 1966; Reeve, Jang, Hardre, & Omura, 2002). Similarly, autonomy does not necessarily equate to acting without regard to constraints or demands (Dworkin, 1988). An individual may exhibit self-determined autonomy even when acting in accordance with external demands when he or she fully concurs with or endorses the value of the activity (Ryan & Deci, 2006).

Furthermore, autonomy does not suggest an infinite number of options, choices or decisions to make. Schwartz (2000) suggested that having too many choice opportunities may prove overwhelming. Ryan and Deci (2006) concurred that having too many choices can prove daunting for the individual, and clarified that SDT advocates facilitating the individual’s experience of volition rather than providing unlimited choice options: One can have many options yet fail to perceive autonomy, instead feeling resentful toward investing effort associated with decision-making. Alternatively, providing only a single option may improve perceived autonomy when one truly endorses that option. Fostering autonomy and intrinsic motivation involves more than providing opportunities for making individual choices and decisions; autonomy involves endorsement of the activities in which one engages.

Autonomy support facilitates a student's pursuit of individual goals and their endorsement of externally assigned activities. Reeve and Jang (2006) defined autonomy support as "the interpersonal behavior one person provides to involve and nurture another person's internally locused, volitional intentions to act" (p. 210). Students perceive autonomy in their learning when teachers support their interests, preferences, values, and psychological needs (Deci & Ryan, 2000). Supportive learning environments provide a compelling rationale for why and how assignments are designed; provide opportunities to make individually relevant and interesting choices so students express psychological needs and integrate them into the classroom activities; allow time to work on a problem in individual ways; empathize with students' perspectives, and avoid externally-controlling terms (e.g., "you must") (Reeve & Jang, 2006).

Several researchers have documented the positive influence of teacher autonomy support on students' engagement, concentration, time management, self-regulation, and academic performance (Jang, Reeve, & Deci, 2010; Reeve, 2006). Students may evolve and exhibit emotional connections with instructors who support their autonomy (Ryan, La Guardia, Solky-Butzel, Chirkov, & Kim, 2005). In one college organic chemistry class, perceptions of instructor autonomy support were associated with increases in student autonomous self-regulation, perceived competence, and interest and enjoyment, and corresponding decreases in anxiety. Changes in autonomous self-regulation, in turn, were positively associated with students' course performance (Black & Deci, 2000).

Related research indicates that autonomy support is also enhanced by providing structure. When combined with structured guidance, autonomy support proved effective in fostering students' self-regulation (Reeve, Jang, Carrell, Jeon, & Barch, 2004; Sierens et al., 2009). Among elementary school students engaged in a digital learning task, providing both autonomy support and structure yielded positive effects on both intrinsic motivation and learning outcomes (van Loon, Ros, & Martens, 2012). This suggests that when instructors provide guidance, directions, and expectations in autonomy-supportive ways, they promote student engagement in student-centered learning and obtain desired learning outcomes. Conversely, when autonomous motivation is undermined, performance decreases especially when applied to flexible, heuristic, creative, or complex capacities (Deci, Koestner, & Ryan, 1999). Therefore, autonomy is paramount where students engage complex problems that require more than recall of basic knowledge and skills.

Scaffolding

Many students, especially novices and those with limited background and experience in a domain, require explicit structure to make sense of content, make informed decisions, monitor their progress, and adapt to emergent challenges. In effect, scaffolds make available the knowledge, skill, strategies, and expertise of more knowledgeable others (Vygotsky, 1978). Scaffolding supports participation and engagement as learners engage problems within the individual's zone of proximal development. When the student demonstrates an acceptable level of competence, the scaffold is gradually faded to promote independent functioning. In SCLEs, scaffolding assists students to participate meaningfully by supporting efforts to identify relevant goals, pursue and monitor progress toward those goals, reconcile differences between existing understanding and concepts yet to be learned, and construct and refine artifacts (Hannafin, Hannafin & Gabbitas, 2009). Scaffolding may involve activation of prior knowledge and providing tips, cues, strategies, and explicit directions (Brush & Saye, 2000; Azevedo & Hadwin, 2005; Sharma & Hannafin, 2007).

Scaffolding interactions can be regarded as either dynamic or static (Kim &Hannafin, 2011). Dynamic scaffolds are flexible, interactive, and adaptive to students' progress, real time needs, and cognitive demands. Due to their dynamic nature, these scaffolds have been found to be inconsistent in implementation frequency, quality, and impact on student learning (Hannafin, Hill, Land, & Lee, 2014). In contrast to dynamic scaffolds, static scaffolds are predefined and are often provided within fixed guidelines regardless of the student's individual progress. Static scaffolds are often presented in the form of text, tool, or technology. Static scaffolding has proven effective in learning basic information but is often ineffective in promoting the reasoning and thinking skills valued in SCL (Kim & Hannafin, 2011).

Several studies have examined the effect of adaptability of scaffolding to learners' individual needs. In Azevedo's study (2005) on the effects of scaffolding on self-regulated learning, students who received dynamic scaffolds demonstrated increased activation of prior knowledge, greater changes in mental models, more frequent and regulated planning and monitoring of progress toward learning goals, and help seeking and effective strategy use than those who received either fixed or no scaffolding. Clarebout and Elen (2006) compared dynamic with static pedagogical agents to support complex problem solving skills in an open-ended learning environment. College students who received adaptive (dynamic) advice outperformed those who received advice at fixed time intervals.

Scaffolding purposes have been categorized as *procedural* (how to use learning environment features), *conceptual* (what knowledge to consider), *metacognitive* (how to think about the problem), and *strategic* (what the alternative strategies are) (Hannafin, Land, & Oliver, 1999). Scaffolding sources are instructors, peers, and technology in a formal setting (Kim & Hannafin, 2011). Some scaffolds adapt to dynamic changes in the state of student understanding per individual needs and progress. Others are static (fixed) within the environment and do not evolve to accommodate shifting needs of individuals.

Procedural scaffolds focus on operational, how-to features of the learning environment (Hannafin, Land, & Oliver, 1999) and provide cognitive structure to assist students in completing tasks (Sharma & Hannafin, 2007). Procedural scaffolds could walk students through the process of identifying instructional goals, determining the paths to achieve their goals, selecting resources and tools, and making inferences. This scaffolding function reduces the learners' cognitive load by providing step-by-step directions and directs their attention to important aspects of the task.

Procedural scaffolds alone, however, are typically insufficient to facilitate student-centered learning and are most effective when applied in combination with complementary scaffolds. For example, Oliver and Hannafin's (2000) study revealed that eighth grade students relied primarily on procedural support during a science problem solving unit, which offered detailed directions regarding what and how to complete problem- solving activities. Few students, however, accessed or applied complementary conceptual and metacognitive scaffolds, resources or suggestions. Similarly, Davis and Linn (2000) scaffolded eighth graders' completion of specific science problem-solving activities, such as analyzing claims, identifying weaknesses, and critiquing the claims. Although activity prompts helped students complete the activity, they engendered fragmented knowledge of individual steps rather than the connections between and among the separate steps. Both conceptual and strategic scaffolds were needed to deepen the understanding of knowledge and strategies involved in the inquiry.

Conceptual scaffolds assist in linking and organizing knowledge related to a topic. This helps students to determine what they already know, what they need to learn, how existing knowledge and to-be-learned content are related, and how new content can be organized with respect to domain knowledge (Bulu & Pedersen, 2010). Conceptual scaffolds have been applied to help learners to identify and evaluate relevant domain knowledge across multitudes of resources and to integrate new with existing knowledge structure. MacGregor and Lou (2005) examined the influence of a conceptual scaffold on fifth graders' WebQuest inquiries. The authors used a study guide and a concept map template to scaffold the collection of relevant information and to connect information associated with the WebQuest topic. They reported that the study guide scaffold helped to identify the information needed to populate the concept map template by providing organizing and synthesizing cues. Chen and Bradshaw's (2007) knowledge integration scaffolds emphasized critiquing, interpreting, and explaining key concepts in educational measurement. Undergraduate students read an instructional passage on reliability and validity as they worked to address an ill-structured problem. Students who received knowledge integration scaffolds made intentional efforts to identify concepts and relationships and performed significantly better when developing and justifying solutions and considering alternatives.

Strategic scaffolds support individuals as they address challenges and consider multiple alternatives (Kim & Hannafin, 2011) by stimulating consideration of alternative strategies. Pedersen and Liu (2002), for example, examined the influence of an expert-based tool on sixth graders' performance on solving novel science problems during *Alien Rescue.* They compared modeling cognitive thinking process with providing didactic instruction on strategy use, and giving strategic advice. The modeling group posed significantly more relevant questions and performed significantly better than the other two didactic and strategic advice groups. Among novices, strategic scaffolding in the form of expert modeling of thinking processes enabled students to apply approaches employed by experts.

During peer interactions, students exchange ideas, suggestions, and feedback with one another. Ge and Land (2003) examined the effects of peer interaction on undergraduates' information system design processes. By working in groups, the students were able to identify alternative views on the problem, build upon one another's ideas to develop solutions, consider more factors and information, and offer suggestions and feedback. Reflections on others' perspectives encourage students to assess potential shortcomings in their individual approaches and eventually modify their approach to ultimately improve performance (Choi et. al., 2005).

Metacognitive scaffolds guide in goal setting, planning, organizing, self-monitoring, and self-evaluation (Zimmerman, 1990). Metacognitive scaffolds can support the development of two critical skills: domain knowledge acquisition and general self-regulatory strategies. For example, Wolf, Brush, and Saye (2000) provided metacognitive scaffolds to support eighth graders' writing of a historical event. They used domain specific guides that directed students to consider significant aspects of the event as well as self-regulatory guides that prompted them to reflect on progress and plan for subsequent activities. Their findings indicated that students who received scaffolding both wrote better accounts of the events and exhibited more task-focused and self-directed behaviors than those who did not.

Kim and Ryu (2013) promoted metacognitive awareness by capitalizing peer reciprocal feedback through a web-based formative peer assessment system (WFPAS) in a postsecondary Instructional Design course. The prompts depict the sequential metacognitive learning process, where students plan, draft, peer review, reflect on and revise their solutions to ill-structured instructional design problems. They suggested that the stages of formative peer assessment are similar to self-regulated learning processes. Peers reviewed the draft and suggested alternatives and together students discussed their solutions. Students monitored their learning and modified strategies and the final product reflected the peer suggestions.

Scaffolding sources may include peers, instructors, and technology. It can be more effective when scaffolding sources are provided together rather than applied separately. Roschelle et al. (2010) tested a mixed (peer and technology) scaffold with social incentives to ask questions, give explanations, and discuss disagreements about mathematics among peers. Fourth grade students who worked with peers in social activities using handheld networked devices performed superior on fractions problem solving than those who worked alone or on a desktop computer, suggesting group feedback and social processing through appropriate technology enhance engagement and learning. Similarly, Kim & Ryu's (2013) study also revealed that the combination of technology and peer scaffolding was more effective than either source alone. Students using the Web-based formative peer assessment (WFPAS) technology demonstrated higher levels of reflection and self-regulatory skills and performed better than those who engaged in peer feedback activity without assistance of WFPAS.

Real World Audiences

Consistent with constructionist philosophy, SCL artifacts and products are typically shared with an authentic, real-world audience. The value of artifacts is enhanced when they address real-world concerns and issues (Wigfield & Eccles, 2000). For example, Cohen and Riel (1989) compared students' writing for a course requirement with writing to peers at a distance. Seventh-grade students wrote two compositions on the same topic, one addressed to peers in other countries and the other to their teacher. Significantly higher ratings were reported for papers designed to communicate with peers via computer networks than those written to demonstrate their skills to instructors.

Blogging, a contemporary variant has increased substantially in the digital age. The educational blogs have increased accessibility of artifacts worldwide and invite comments and annotations across authors (Stephens, 2006). Montero-Fleta & Pérez-Sabater (2010) reported positive academic and motivational effects of student blogging in a college English language classroom in Spain. Native Spanish-speaking students documented their study in English in personal blogs and shared blogs concerning topics of academic interest. Students expressed a stronger preference for blogging than previous traditional writing lessons, suggesting that creating and sharing artifacts with an authentic audience motivated students to perform at a higher level. Writing fluency and grammatical construction improved, as active blogging improved student motivation for writing.

Kearney and Schuck (2006) described the influence of sharing student-generated video artifacts among elementary and secondary schools in Australia. Student groups produced and subsequently shared digital videos with their peers. The findings indicated increased student autonomy and task ownership; recognition of real-world audiences was identified as a significant influence on the students' motivation. To solidify the authentic use of artifacts, artifacts can be disseminated to and used by other students in class, future students, and the society at large as well as globally (Sener, 2007).

Engagement in Student-Centered Learning Environments

By supporting student autonomy, scaffolding student engagement, and transitioning from traditional academic requirements to real-world audiences, student performance and engagement should improve. To this end, we propose an integrated framework and associated guidelines for enhancing student engagement in SCLEs: *Own it, Learn it, & Share it* (OLSi). OLSi specifies design assumptions and offers practical guidelines to engage students to identify and clarify learning problems, conduct the inquiry that addresses the problem, and create and share artifacts that embody the reasoning. Factors believed to enhance engagement—autonomy support, scaffolding, and real world audiences—are integrated into the design of the OLSi.

OLSi comprises three sections: *Own it* (develop ownership), *Learn it* (make meaning), and *Share it* (present it to others). Figure 2.3 represents the relationship between the theories, major constructs, and OLSi within the framework for SCLEs. Table 2.3 summarizes the guidelines suggested for the OLSi framework and supporting literature.

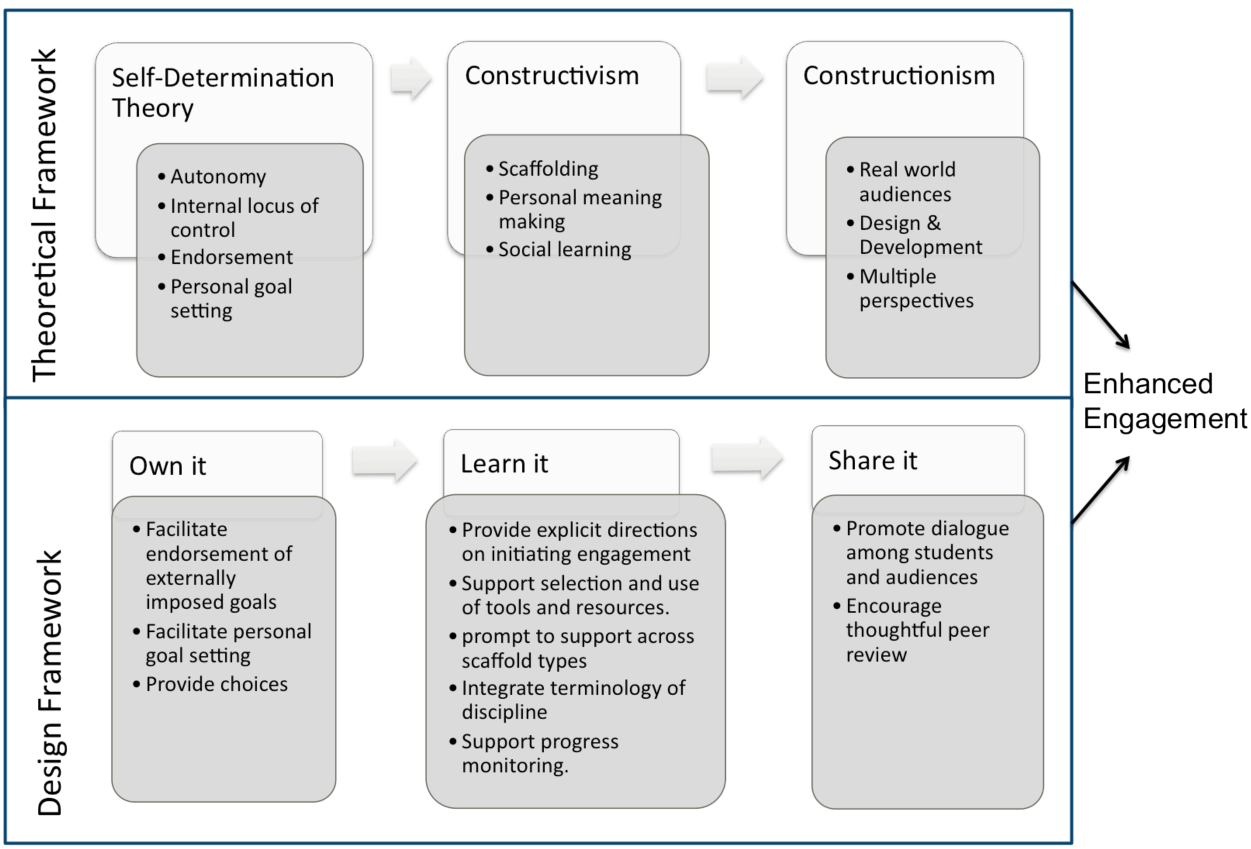

Figure 2.3. Own it, Learn it, and Share it Framework

Table 2.3. Design Guidelines and Supporting Literature

Framework	Guidelines	Supporting literature
Own it	Facilitate endorsement of externally imposed goals.	When an explanation of the purpose and value is provided, they are likely to become personally engaged and motivated to engage (Reeve, Jang, Hardre, & Omura, 2002).
	Provide opportunities to set specific personal goals.	Clear goals increase engagement, persistence, and use of strategies for goal attainment and decrease anxiety, disappointment, and frustration (Locke & Latham, 2002).
	Provide choices.	When offered choices, students tend to spend more time and effort on the activity (Flowerday & Schraw, 2000), perform better, and obtain higher assignment completion rates (Patall & Wynn, 2010).
		Mediate the number and the extent to which students make choices to minimize frustration (Schwartz, 2000).
Learn it	Provide explicit directions on initiating engagement.	Direct instruction supports the acquisition of essential domain knowledge (Schwartz & Bransford, 1998).
	Support selection and use of tools and resources.	Expert models can provide conceptual, procedural, metacognitive, and strategic scaffolding about what to search for, where to look, and whether such material is a valid or useful source (Pedersen & Liu, 2002).
	Prompt to support varying needs.	Prompts have proved effective and been widely used across contexts for conceptual (Chen & Bradshaw, 2007), procedural (Huang, Wu, Chen, 2012), strategic (King 1991), and metacognitive scaffolding (Ge & Land, 2003).
	Integrate the terminology used in the discipline.	Teachers model scientific discourse and have students justify their decisions using the scientific language (Kolodner et al., 2003).
	Support students as they monitor progress.	Students should be able to monitor their own cognitive efforts, reevaluate goals, and modify plans (Shin, Jonassen, & McGee, 2003).
Share it	Promote dialogue among students and audiences.	By sharing, students gain a deeper understanding of others' perspectives (Evard, 1996).
	Encourage thoughtful peer review.	Students gain a fresh view on their own products when comparing one's product to others' (Lundstrom & Baker, 2009).

Own it

Own it is designed to develop personal ownership, regarded as important in SCLEs to promote autonomous motivation (Land & Hannafin, 2000). Ownership can be enhanced when students perceive that instructors support individual autonomy. *Own it* is rooted in three research-based design assumptions.

Design guideline 1. Facilitate endorsement of externally imposed goals.

Autonomy is not limited to an individual's initiatives but also applies to wholehearted endorsement of external expectations (Ryan & Deci, 2006). Students can work autonomously toward external goals when they endorse the value of the activity. To facilitate autonomous motivation, instructors need to communicate the rationale for assignments to students—why the activity is important for their learning and how the activity is designed to facilitate the achievement of the broader learning goal (e.g., course goal). When an explanation of the purpose and value is provided, students are more likely to become personally engaged and motivated to engage (Reeve, Jang, Hardre, & Omura, 2002).

In Kim & Bennekin's (2013) study of a community college remedial mathematics course, a virtual change agent appeared at the beginning of each lesson and related situations to help students perceive the value of the lesson and a reason to pursue a goal. This stage was designed for students to "want" to engage in a mathematics course and became the basis for the subsequent exercises. Students who interacted with the virtual change agent exhibited more positive recognition of the intrinsic value of the course than those who did not access the agent. The initial desire to learn established at the beginning of the semester was sustained throughout the semester.

Design guideline 2. Provide opportunities to set specific personal goals.

Personal goal setting has been widely documented as improving academic performance (Acee et al., 2012; Latham & Locke, 2007; Morisano, et al., 2010; Schunk, 1990). Students clarify their personal goal or outcome, making the value more prominent, and specify paths and milestones to goal completion, thereby increasing its perceived attainability (Wigfield & Eccles, 2000). Students who determined clear learning goals appear to direct attention and effort toward goal-germane activities and stay distant from goal-extraneous activities. The establishment of clear goals also appears to increase engagement, persistence, and use of strategies for goal attainment and decrease anxiety, disappointment, and frustration (Locke & Latham, 2002), and improve grade point average (Acee, Cho, Kim, & Weinstein, 2012).

Own it encourages setting specific personal goals when engaged in an externally imposed activity in anticipation of personal gains from the activity (e.g., pre-med students enduring basic chemistry to become a pediatrician) (Black & Deci, 2000). Although a student's personal goals might have extrinsic value (e.g., grade or graduation), the focus can be placed on instrumental usefulness (Kim, 2012). Keller's (2009) motivational design model emphasizes making the project relevant to students' needs. When students work on personally meaningful projects, they become personally invested in their projects. This enthusiasm can positively influence both the students' attitudes toward the subject matter and their performance.

Instructors can incorporate opportunities for students to document their individual/personal goals after explaining task value and purpose. In Kim & Bennekin's (2013) study, the virtual change agent relates a story about how he overcame previous negative emotions and identified personal goals and a plan to guide his actions. Using a goal contagion approach (Aarts el al. 2004), students were encouraged to adopt the agent's goal as well as set their own specific and proximal goals for mastery learning and to plan their actions in anticipation of positive results.

Design guideline 3. Provide choices.

Choices can enhance perceived autonomy (Reeve & Jang, 2006). The option to choose from among options can increase students' perceptions of control over their actions (Reeve, Nix, & Hamm, 2003). Providing choices facilitates an opportunity for students to address their own goals and interests, which is essential in motivating students (Hidi & Harackiewicz, 2000). When students are offered choices, they tend to spend additional time and effort on the activity (Flowerday & Schraw, 2000), perform better, and obtain higher assignment completion rates (Patall & Wynn, 2010). However, as Schwartz (2000) cautioned, too many choices has proven overwhelming and wasteful for decision-making. According to Ryan and Deci (2006), SDT advocates facilitating the experience of volition rather than overwhelming students with too many options.

Learn it

Learn it scaffolds accomplishment of a goal. SCL proponents suggest scaffolding efforts to formulate questions and inferences, monitor progress, identify and evaluate resources, refine thinking, and construct knowledge (Hannafin, Hill, Land, & Lee, 2014). *Learn it* provides procedural, conceptual, strategic, and metacognitive scaffolding to guide student-centered inquiries. Procedural scaffolds provide step-by-step guides; conceptual scaffolds guide what to consider; metacognitive scaffolds support learning management; and strategic scaffolds provide alternatives to consider (Hannafin, Land, & Oliver, 1999).

Design guideline 4. Provide explicit directions on initiating engagement.

When students have limited prior knowledge and experience, misconceptions and naïve assumptions may influence their SCL processes (Moos & Azevedo, 2008; Shin, Jonassen, & McGee, 2003). A lack of prior domain-specific knowledge is particularly problematic in SCLEs since students initiate inquiries by generating questions based on their own knowledge and experiences (Kim & Hannafin, 2011). Activating existing schema by eliciting prior knowledge has been recognized as an important initial step of instruction (Gagne, 1988; Merrill, 2002). In such cases, direct instruction supports the acquisition of essential domain knowledge (Schwartz & Bransford, 1998). Fixed, directive scaffolds can provide initial procedural and conceptual support to reduce the cognitive load and help students initiate and pursue their goals under way (Hannafin, Hannafin, & Gabbitas, 2009).

Design guideline 5. Support selection and use of tools and resources.

Previous researchers established that students often lacked experience in locating and using resources (Hill & Hannafin, 2001). Thus, unsupported access and use of Web resources can affect the accuracy and credibility of student products. Ineffective and inefficient strategies interfere with learning and cause frustration. Furthermore, many students fail to use support devices available in their computer assisted, open-ended learning environment (Clarebout & Elen, 2006; Oliver & Hannafin, 2000). Expert models provide conceptual, procedural, metacognitive, and strategic support regarding what to search for, where to look, and whether such material is a valid or useful source (Pedersen & Liu, 2002). Experts can also (e.g., teacher or librarian) make visible the unobserved thought processes experts use to guide their actions (Collins, Brown, & Hulum, 1981). Experts and students work alongside, as students observe the expert perform while verbalizing their thinking. Through modeling, students develop mental models of how to apply domain specific knowledge and strategies in context while gaining insights into the reasoning processes of more experienced partners (Collins, Brown & Newman, 1989).

Design guideline 6. Prompt to support varying needs.

Prompts have been widely used across contexts to trigger conceptual, procedural strategic, and metacognitive scaffolding. For conceptual scaffolding, knowledge integration was supported by embedded questions prompts for undergraduate students during Web-based learning (Chen & Bradshaw, 2007). Questions prompted students to consider content in ways to support construction of new or reorganization of existing knowledge.

Procedural scaffolding, in the form of thinking before talking prompts, has been implemented to foster group discussion among graduate and undergraduate students in Taiwan (Huang, Wu, Chen, 2012). Each student recorded initial thoughts and reasoning on their smart phones before group discussion. During group discussion, group members viewed others' written responses via smart phone and collaboratively completed a worksheet, which resulted in more active participation and effective interactions in the group discussion and promoted individual higher-level thinking skills.

Strategic questions guided students as to how, when, and why to use cognitive and metacognitive strategies to support problem solving. Strategic question training facilitated critical thinking and high-level elaboration of lecture content in education methods courses for college students (King, 1990) and improved computer-assisted spatial reasoning and general problem solving among fifth graders (King, 1991). Students who received reciprocal questioning strategy training out-performed peers who used discussion, questioning-responding without guidance, or independent review. These studies suggested that guidance on how to pose questions and obtain explanation, justification, information, and methods is essential since students often fail to ask strategic questions without having explicit support to do so.

Metacognitive scaffolds have helped both college students focus attention and monitor learning through elaboration and supported graduate students' thinking via think-aloud protocols. Ge and Land (2003) reported that students performed better in both cognitive and metacognitive activities when responding to question prompts. Additionally, graduate students participated in a case study to examine the effects of cognitive and metacognitive question prompts during online, ill-structured problem solving activity (Ge, Chen, & Davis, 2005).

Design guideline 7. Integrate the terminology used in the discipline.

Previous researchers cautioned that students' focused on arts and crafts as a construction activity rather than the domain aspects of science (Hmelo et al., 2000). In a middle school science construction project, Kolodner and colleagues (2003) overcame this challenge by encouraging teachers to model scientific discourse while having students justify their decisions using appropriate scientific language. In postsecondary engineering education, mathematics is regarded as "the language of engineering" (Dym, 1999, p. 6). Before engaging in engineering design curricula,students complete prerequisite mathematics courses. Dym (1999) suggested that subsequent engineering curriculum should expand upon and build from mathematical languages as well as languages of design, such as graphical representations and computing. We need to articulate connections between constructions and subject learning by integrating the subject specific terms into the design process.

Design guideline 8. Support students as they monitor progress.

Students who are unfamiliar with student-centered learning can become frustrated, and shift their focus to reaching perfunctory, immediate outcomes. SCL requires that "students possess not only the content knowledge but also regulation of cognition, including modification of plans, reevaluation of goals, and monitoring of one's own cognitive efforts" (Shin, Jonassen, & McGee, 2003, p. 23). However, research confirms that students experience difficulty monitoring their progress, managing their time efficiently, and identifying areas in which they need assistance (Brush & Saye, 2000). Metacognitive scaffolds support the monitoring of independent inquiry. Expert modeling, cognitive apprenticeships, question prompts, peer feedback, and step-by-step check points support students as they monitor progress, reflect on what has been done, seek clarification, and identify needs.

Share it

Share it is designed to enhance student engagement by presenting and sharing products with real world audiences. Constructionists argue that learning is optimized when students design and produce tangible artifacts to embody understanding and to share among others. Sharing artifacts facilitates personal reflection and social interaction (Harel & Papert, 1991). The creation of artifacts requires that students think tangibly as they design, develop, and present. As students share and exchange products, they develop stronger personal investments in their learning and artifacts; furthermore, understanding is mutually enhanced by comparing perspectives and negotiating, adjusting, and confirming individual understanding.

The advent of Web 2.0 has blurred boundaries between the producers and consumers. Students can create and readily share digital representations and exchange feedback among collaborators across the globe (Andersen, 2007). A number of contemporary scholars have examined Web 2.0 sharing applications in education. Redecker et al. (2009) examined the impact of innovations in education and training in Europe and noted in stances where Web 2.0 tools have been applied to create and share knowledge, increase motivation and participation, and promote diversity and multiple perspectives in a social learning environment. Augustsson (2010) reported that the integration of Web 2.0 (i.e.,VoiceThread) in a Swedish face-to-face postsecondary social psychology course increased involvement in group activity as well as identification of the individual's and peer's thoughts and emotions. Bower, Hedberg, and Kuswara (2010) aligned technological, pedagogical, and content knowledge as a framework for Web 2.0 design. Lee (2011) proposed guidelines for sustaining student motivation using Web 2.0 technologies to produce student-generated content.

Design guideline 9. Promote dialogue among students and real-world audiences.

Students operationalize thinking by creating products whose value can be understood by others with varied domain knowledge. They need to communicate findings in ways that epitomize the depths of their understanding as it relates to everyday issues. Students self-evaluate their understanding to assess options to translate into artifacts to represent intended interpretation. Audiences, in turn, provide different, potentially complementary or competing, perspectives on the product which affords opportunities to consider alternatives. By sharing creations, students gain a deeper understanding of others' perspectives and ideas related to the artifact (Evard, 1996).

Design guideline 10. Encourage thoughtful peer review.

During peer reviews, participants assume the role of trained peer reviewers and exchange written and spoken feedback on formative drafts and prototypes (Hansen & Liu, 2005). Asking for and receiving alternative explanations enables students to assess and potentially revise their representations (Lundstrom & Baker, 2009). Cho and Schunn (2007) found that undergraduate students' informal science learning improved when they received feedback from multiple peers through SWoRD—a web-based scaffolding system, versus those who only received feedback from a single expert.

However, engagement and support for peer review are often needed but overlooked. Although often incorporated to promote social interaction and learning (Trautmann, 2009), students report negative attitudes toward peer review (Yang & Tsai, 2010). Many students lack the experience or guidance needed to provide constructive reviews. Novice student reviewers, for example, may provide superficial or uninformed feedback due to limited background knowledge and experience. Effective peer review processes are facilitated and monitored using complementary scaffolds, such as question prompts (Ge & Land, 2003) and coaching (Lam, 2010). Guiding questions can orient students' approach to reviewing peer's products and articulating their perspectives on them.

Unresolved Issues and Directions for Future Research

There is dearth of evidence related to how students and teachers perceive student-centered learning, how student-centered learning is practiced, and the influence of instructor-student belief on teaching practices and student learning. Ertmer (2005) documented gaps between teachers' beliefs and their actual technology integration practices; Polly and Hannafin (2011) documented the trend among elementary school mathematics following reform-based professional development. Song, Hannafin, and Hill (2007) proposed a strategy to reconcile differences between their beliefs and practices of instructors' and students'. These studies and strategies may provide evidence of the need to align beliefs and practices and an approach to implement student-centered learning in formal education, but little current evidence validates reconciliation in practice or sustained implementation over time.

In addition, few validated measures are currently available to document instructor and student beliefs and practices. Researchers will require validated and field-tested instruments to assess the their influence on both engagement as well as learning processes and outcomes. While isolated efforts have been reported in the science (e.g., Erdogan, Campbell, & Abd-Hamid, 2011), teachers of adult learners (e.g., Conti, 1990), autonomous motivation (e.g., Gorissen, Kester, Brand-Gruwel, & Martens, 2013) and perceived autonomy in education (e.g., Black & Deci, 2000), we will need more consolidated, integrated models that address varied nuances and depths of applications across.

Advances in assessment of student-centered learning processes, products, and outcomes are also needed. Students monitor goals and means formatively to adapt as well as summatively to certify attainment. Some researchers have incorporated standardized norm- or criterion-referenced assessments as well as alternative assessments such as self-assessment, peer assessment, rubrics, feedback, portfolios, and exhibition (Andrade, Huff, & Brooke, 2012). The Jasper program (Cognition and Technology Group at Vanderbilt, 1992), for example, balanced expected performance measures with indicators of how well students were able to identify, evaluate, pursue and resolve problems. In addition to standardized test data, student performance was assessed using alternative assessments such as Basic Math Concepts Test, Word Problem Test, Planning Test, and Math Attitudes Questionnaire. Jasper students reported comparable performance on standardized measures but superior performance in complex problem solving, planning and subgoal comprehension questions, and improved attitudes toward mathematics. Further research is indicated to increase confidence in students’ self-assessment of their individual progress, outcomes, and strategies to manage their learning.

Finally, whereas considerable scaffolding research and theory has been documented, we have limited understanding as to how scaffold can accommodate varying levels of student preparedness and motivation. For example, at-risk students, refugee youths, and English as Foreign Language students, who under-perform historically and lack understanding and skills to engage their learning environments (Nelson, Quinn, Marrington, & Clarke, 2012), present needs that cut across varied domains, motivation, and effectiveness in managing individual learning decisions. For the range of individuals, we need to scaffold uniquely different needs in order to empower them to assume ownership for their learning.

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CHAPTER 3

WRITING STORIES IN THE SCIENCES[2]

[2] Lee, E., & Maerz, J. C. Submitted to the *Journal of College Science Teaching*, 11/08/2013.

Abstract

Writing stories is advocated as an excellent means to learning the process of science; however, little is understood about students' experiences of engaging in story writing in postsecondary science courses. Our study was designed to improve the practice of using stories in the sciences by examining students' lived experience through interviews, surveys, observations, and document analysis. Students perceived the learning goal as public outreach and networking with the science community rather than learning the process of science; and they reported difficulty blending science into narratives and requested structured guidance throughout the process, without which some found it difficult to engage in this autonomous, non-traditional assignment. We integrated students' suggestions into the next implementation while keeping some elements open-ended. Narrative writing holds potential for gaining more hands-on knowledge of the processes of science and communicating scientific findings to a general audience as well as enhancing self-knowledge about academic interests.

Keywords: writing, narratives, science education, student-centered learning

Introduction

"This is a science class, not an English class. Writing has nothing to do with science."

– Anonymous student comment

Because written lab reports are prevalent in the sciences, teachers often assume students are accustomed to writing, understand its importance, and are comfortable with different forms of writing in communicating scientific information. However, as the anonymous quote above illustrates, the importance of writing in science and science education is not obvious to all students. Writing is a vital component of rigorous science education (Tessier, 2006). Writing is a complex cognitive task that supports knowledge construction by establishing connections between prior domain knowledge and knowledge about discourse (Bereiter & Scardamalia, 1987). Writing requires reflection and meaningful expression of the learned material and is usually processed through multiple revisions, promoting additional research and examinations of drafts (Hayes & Flower, 1986).

Bean (2011) asserted that writing teaches critical thinking skill that are parallel scientific reasoning skills for posing questions or hypotheses, gathering and analyzing data, and making logical arguments. Prain (2006) argued that teachers should encourage science students to write in diverse forms for different purposes since diversified writing helps students translate technical terms into everyday language, connect emerging to existing knowledge, and clarify networks of concepts in science topics. Yurco (2014) observed increased ownership and confidence when undergraduate students wrote their own diagnostic cases for case studies in an introductory neurobiology course, subsequently improving the understanding of material, active discussion, and critical thinking.

Narratives (stories) are recognized as important to understanding the processes of scientific investigation. National Science Education Standards mandate that students need to learn not just basic scientific facts and theories, but also the methods and processes of scientific investigation (National Research Council, 1996). Clopton (2011) claims that because traditional science papers are organized in a manner to convey information concisely so that methodologies and results can be critiqued and replicated, they are not effective at communicating research to a general audience, nor highlighting the human process of scientific discovery. He notes that people are accustomed to stories as a means of understanding how present and past events relate and how actors make decisions and conduct the course of actions in those events; therefore, he argues reading and writing narratives promotes an understanding of the processes of science and human endeavors associated with scientific research (Clopton, 2011).

Martin and Brouwer (1991) assert that narratives facilitate a personal engagement and full exploration of the meaning and reveal subtle ways in which scientists navigate the process of science. Among middle school students, writing stories improved familiarity with science issues, the understanding of scientific concepts, and interest in science (Ritchie, Tomas, & Tones, 2010). At the college level in the United Kingdom, underlying conceptual chemistry was presented as a narrative situated in a context that demonstrated coherent cause and effect and depth of meaning, and this was arguably more effective for conceptualizing scientific concepts and processes than presenting the same concepts in the traditional, context-free text (Burton, 1994).

While writing narratives is promoted as an effective means for science learning, little is known about what and how students learn through this process. This study sheds light on how instructors can successfully implement story-writing in the sciences. We seek to understand postsecondary students' experiences by exploring the steps students take to complete this assignment: by identifying difficulties; by examining resources and guidance used, and by determining potential areas for modification. This phase of our study is not a summative evaluation of the effectiveness of writing narratives, rather a needs assessment to ultimately improve practice.

The Present Study

This study took place in an upper-level undergraduate/graduate organismal biology course for both majors and non-majors at the University of Georgia (UGA). The class consisted of two weekly 90-minute lectures and a weekly three-hour lab. Twenty-four students (19 upper classmen and 5 first-year graduate students) participated. All undergraduates had previously completed compulsory English composition courses in their freshmen year, which had the stated objectives as students focused on informational, analytical, and rhetorical writing; gained practice in writing papers by discovering ideas and evidence, organizing, and revising; addressed papers to various audiences; critiqued their own writing and others'; and developed a sense of voice appropriate to subject, purpose, context, and reader-expectations. In addition, all the students had taken introductory science courses that required traditional laboratory exercises including writing standard lab reports. The instructor assumed that students were familiar with research methods and library databases because they were upper classmen or graduate students.

Research Narratives

In order to enhance the heuristic understanding of scientific processes, the research narrative project was first implemented in spring 2012 in a postsecondary organismic biology course. Each student wrote a story about a specific research project of their choice to illustrate a larger concept and scientific process for the general public. The syllabus stated the learning objectives of the narrative were: (1) to use stories to facilitate the understanding of science as human endeavor and the process of conducting scientific research; (2) to use interviews and literature to expose students to the broader community of biology and the perspectives of other researchers; and (3) to explore careers related to biology and to network with professionals.

While engaged in the research narrative, students were expected to select a topic or an organism related to the course, explore peer-reviewed and popular articles, interview at least one researcher outside the University, submit first drafts, perform peer-reviews and self-critiques, and revise stories for a final submission. Scaffolding was provided through a variety of resources and structured guidance, including a detailed syllabus with a description of the assignment and rationales why and how this assignment could be beneficial; possible interview questions, and expected challenges; a database of potential interviewees, incremental milestones; a rubric; examples of professional stories from *National Geographic*; and peer and instructor feedback on early drafts.

Student-centered learning environments

Students wrote their research narratives in student-centered learning environments (SCLEs). Student-centered learning has gained increasing emphasis in college science classrooms (Walczyk & Ramsey, 2003). In SCLEs, students work relatively autonomously and direct their projects. Students not only decide what to write about but also explore and select a variety of resources, plan and monitor their progress, refine thinking, and produce shareable artifacts (e.g., narratives for the general public) (Hannafin, Hill, Land, & Lee, 2014). In the classroom level, the instructors promoted to create a SCLE. Not only the research narrative project was representative of student-centered approach, but also the entire culture of the course was student-centered. The instructor has emphasized and encouraged students to take responsibility for their own learning and work autonomously to complete assignments. For example, students teach themselves and peers in a given topic during lab and take charge on creating an inventory of organisms in the assigned field.

Procedures for Assessing Student Experiences

We used a mixed-methods design incorporating a survey, interviews, observation, and document analysis (Creswell, 2013). This study was approved by the University's Institutional Review Board. All students were assured that student participation was entirely voluntary and would not influence their grades on the assignment. Students could choose to participate in one or all of the surveys and interviews and give the researcher access to their writing artifacts and associated grades. Students received extra credit for participating in the interview, but no incentives were given for any other research-related activities.

The survey was designed to collect demographics and ask six Likert-Scale questions (e.g., how would you rate the difficulty you experienced translating the technical terms?) and 4 open-ended questions (e.g., what would you recommend the instructor to change for the next time?). It was administered upon completion of the project. Among the twenty-four students enrolled in the class, nineteen students took the survey (response rate: 79%): fourteen undergraduates and five graduates (six males and thirteen females). Likert scale items were ranked in order using descriptive statistics in Microsoft Excel.

The first author conducted semi-structured, one-on-one, thirty-minute interviews with one graduate and six undergraduates upon the completion of the assignment at the end of the semester; analyzed course documents (the syllabus, rubric, peer review, and self-critique templates); and observed a peer review session during the semester. The first author also interviewed the instructor three times before the course, after the peer review, and after the course for a total of 150 minutes. Qualitative data from the interviews were transcribed and combined with observation field notes and document analysis data for coding. Thematic analysis through constant comparison and axial coding was used to analyze qualitative data from the constructivist perspective in which we interpret diverse notions of what occurred (Corbin & Strauss, 2008). The data were coded into conceptual clustered matrices to categorize key themes using inductive analysis. All names are pseudonyms.

Students' Project Completion Process

Students reported the use of a variety of steps to complete the research narrative project. Figure 3.1. represents the steps of completion and clusters of associated experiences coded from the interviews and the observations. Students assumed responsibility for identifying, contacting, and interviewing a researcher; investigating the researcher's projects; and writing the narrative. Some students appreciated the student-centered, open-ended nature of the assignment; others showed differing attitudes toward the more autonomous and non-traditional assignment. Students used the syllabus and rubric as primary sources for understanding the requirements. Although the instructor's primary objective was to build an understanding of scientific processes, students recognized this activity as a means for public outreach, making connections to current research and researchers, and personal engagement with the field. Some excerpts from student interviews are presented below based on their responses to the question about the goal of this project:

> *... because outreach to the public is the main way to get funding. So, being able to convey technical information in a way that people can understand so they will get on board with what you are trying to do. I understand that is an important skill for a scientist.* (David)
>
> *this might be a really good project for people learning about different work that is going on out there and getting to meet people and learning how to approach them.* (Sara)
>
> *It seems that everyone who is good in this field has a lot of contacts within the field …. The other part of it was to get you more interested in this field and make it related to something you personally care about ...* (Leila)

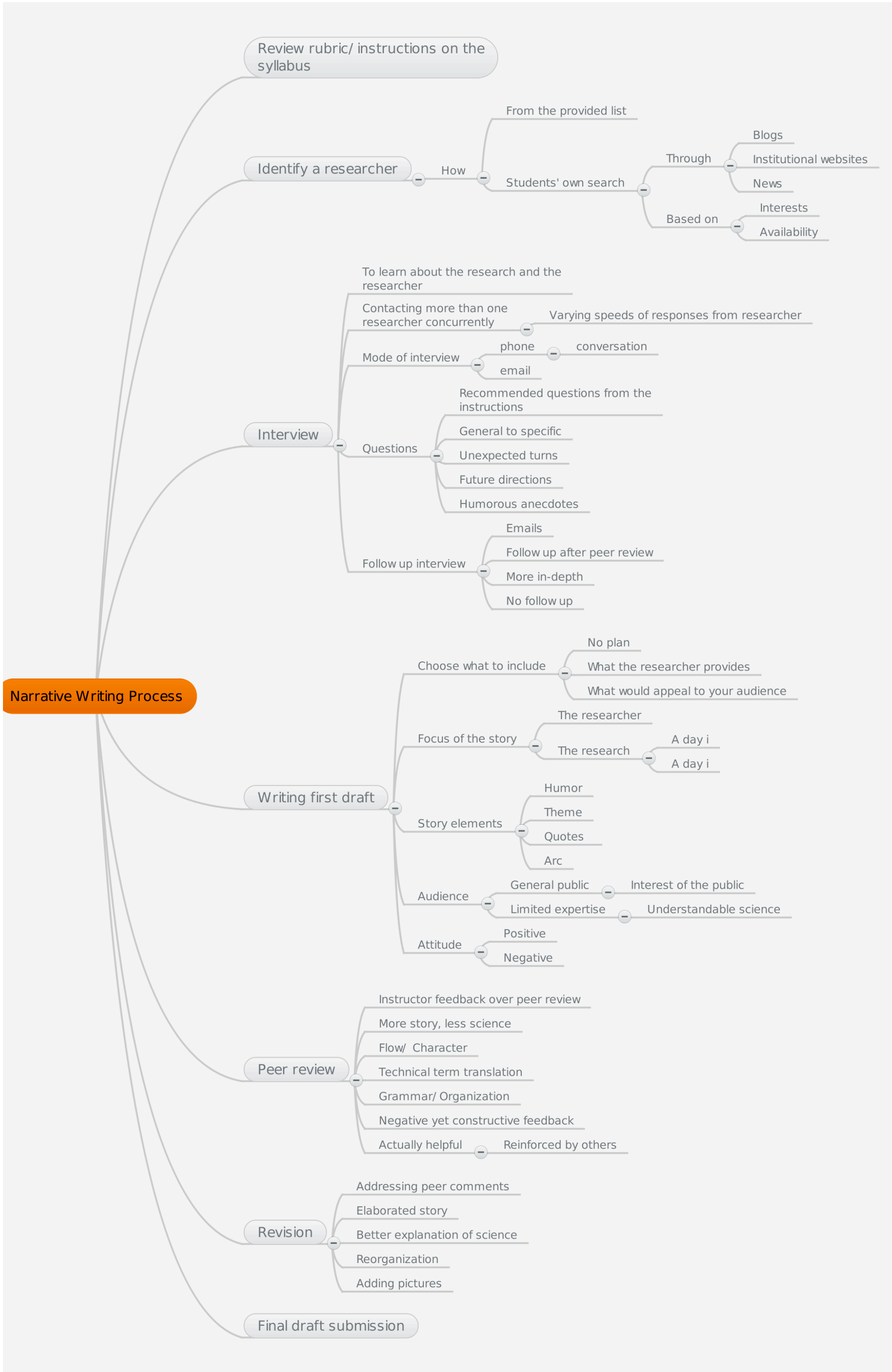

Figure 3.1. Narrative writing process

Many students identified a researcher based on their personal, academic, and career interests. One student chose a researcher based on approachability. Sixteen selected the researchers for their stories from the database provided by the instructor; others identified the researchers from an Internet search or contacted someone they knew. Student experiences with researcher responsiveness varied; several reported responsiveness was a large factor in determining who they interviewed and the theme of their stories as illustrated in the following quotes:

> *I am in a neurobiology class right now. It kinda tied into two classes, which I found very interesting. It worked out for me that I found somebody who is doing the topic that I thought was cool.* (Megan)
>
> *I am a pre-med. I wanted something that had to do with frogs, amphibians, reptiles, and whatever else. Stuff that also have something to do with medicine. ... He worked for the medical school. It was the main thing that appealed to me. I knew he was using the amphibian skin to create drugs, which appealed to me because that's what I want to do for the next four years.* (Leila)
>
> *This guy wasn't listed in the recommended list of people. He has been in the news quite a bit. ... I kind of looked up the zoo and got his contact information and sent him an email and gave him a call.* (David)

Students reported using a combination of given questions and questions they tailored based on their personal interests or situations unique to the research project, including how the researcher became interested in the field, what led the researcher to do the specific study, what it was like to execute a specific research project, what difficulties were faced and overcome, and what was envisioned as future directions for the research. Although the majority of students reported positive experiences conducting interviews, many also reported difficulties in acquiring the scientific information they felt they needed.

Most students used the researchers’ responses as a dominant source of information. Additionally, students reported using the researchers’ publications as well as websites, blogs, news sources, and magazine articles. However, only a few reported the use of primary sources. At the end of the semester interview, the instructor identified the overreliance on interviews and limited use of primary scientific papers as a significant flaw that should be addressed in future classes. While he valued the networking opportunity, he did not anticipate students would limit their sources so narrowly. He felt that having students conduct more research from primary sources would reduce their dependence on the interviews, which could enhance but not limit the development of stories.

Students reported using storytelling elements described in the rubric, such as story arcs (rising action, climax, falling action, and conclusion), character development and scene-setting. Many students reported using scientific terms and jargon without translating them for a lay audience as illustrated in the following quotes:

> *The more you get into a field, the harder it is to explain it because you think everybody knows this term. ... I think it's important to be able to explain science to non-science people.* (Jessica)

> *I think it's important to get through to the audience we are writing these papers for. The general public isn't going to be interested in the topic as much as they are interested in the person. I think that's really the main focus of the narratives. Definitely some science, so there is a purpose to it. But at the same time you've gotta have that personal touch.* (Matthew)

Students held varying opinions about the value of peer review and self-critique. For self-critiques, students summarized peer comments, reflected them against their own judgment, and prioritized revisions. All interviewees reported placing a premium on instructor feedback over peer feedback when revising. Several wanted more guidance on how to revise which are exemplified in the following quotes:

> *I tried to explain things a lot more. ... I would read through different things people said. Try to target things that are repeated.* (Sarah)

> *The critique part was helpful, but what was helpful about it was that it made me feel pressured to do the changes that I told [the instructor] I would do. Or else I would have not done the same changes.* (Leila)

Difficulties

Table 3.1 displays the rank order of areas of difficulty and the percentage of students who reported either difficult or very difficult in the survey.

Table 3.1. *Difficulty Experienced While Completing Research Narrative (N=19)*

Areas of Difficulty	% of responses reported difficult
Writing To Tell A Good Story	84.2%
Planning Out What to Do Next	84.2%
Conveying Scientific Information to a Layperson	78.9%
Critiquing My Own Work	73.7%
Identifying Content to Include in My Narratives	73.7%
Understanding Why I Have To Do This	68.4%
Critiquing Someone Else's Work	63.2%
Motivating Myself to Do It	63.2%
Contacting and Interacting with The Researcher	52.6%
Understanding Content	36.8%
Having Someone Critique My Own Work	15.8%

The survey results and interview responses indicated students struggled most with the student-centered inquiry process and creative writing for the general public. Ten reported difficulty contacting and interacting with their target researchers due to unresponsiveness even after those individuals had agreed to the interviews. Surprisingly, during the interviews, some students reported difficulty in locating and understanding scholarly articles, although researching scholarly materials was covered in their compulsory writing course, and most students reported having taken a course covering research methodologies.

Students reported first having to understand how storytelling differed from writing scientific reports. Despite having had college courses in creative and rhetorical writing, many students said they did not understand how a narrative works in the sciences. Students reported significant challenges in blending science into the story and conveying research processes and scientific information to lay audiences.

Students also reported difficulties in metacognitive aspects of the assignment such as understanding the rationale and value, planning, and self-critiquing. The interview data showed that two students regarded the activity as irrelevant to their interests or academic and career goals. Three students strongly disliked the assignment and did not find the activity constructive.

Useful Guidance

Students reported several useful components and recommended improvements. Table 3.2 presents the rank order of useful guidance and resources designed and provided by the instructor and the percentage of students who selected the options either "useful" or "most useful" in the survey.

Table 3.2. *Useful Guidance While Completing Research Narrative (N=19)*

Guidance and resources	% of responses reported useful
Feedback on the First Draft	94.7%
Rubrics	94.7%
Instructions Provided in the Syllabus	94.7%
Opportunity to Revise	84.2%
Peer Review	78.9%
Individual Discussions with the Instructor	78.9%
Self-Critique	68.4%
Example	47.4%

Students ranked the instructor's feedback on the first draft, instructions, and the rubric most useful along with revision opportunities between the first and final drafts. The example narrative was ranked as least useful. Some students found their own model narratives online. Few sought individual discussions with the instructor, teaching assistant, or writing tutor, but those who did found these resources useful. Only a few reported that the self-critique was valuable because it made them think, plan, and be accountable for the changes they felt necessary for their final draft.

In addition, students recommended providing better distinctions between narratives and other forms of writing, more guidance in creative writing, “realistic” examples of science narratives, previous student examples, a more detailed rubric offering finer grading criteria, and specific page limits. Moreover, students recommended stressing to future students the need to start early and choose a topic for which they feel genuine passion. In the following section, we provide our reservations for this finding and adopted modifications for future practices.

Discussion and Future Directions

Through the research narrative, students could work autonomously on a story about scientific research to better understand the scientific process as a human endeavor and foster personal connections to both the course content and people within the larger scientific community. A number of paradoxes are apparent among the instructor’s assumptions, the activity’s structure, and student perceptions.

First, a discrepancy was evident between intended learning goals and observed goal accomplishment. The instructor’s primary objective was for students to recognize that scientific processes are human endeavors; however, students failed to recognize this and instead focused on peripheral objectives. During interviews, students noted several concerns about misunderstanding the instructor’s intention: public outreach, making connections to current research and researchers, and personal engagement with the field. As such, students’ end performance deviated from the instructor's goal. A similar misalignment was observed in Tao (2006) study, in which secondary students read and interpreted stories about scientific discovery (e.g., The story of penicillin) in an idiosyncratic way.

One modification for future courses is to increase the weight placed on the scientific content and reduce the weight of the story. Initially, the scientific content and the quality of the story were weighted equally; however, students reported focusing a great deal on telling a good story at the expense of rigorous content on the scientific questions and processes. Because the primary objective of the science narrative is to foster a better understanding of science, shifting the weight of the rubric may reduce students' concerns about writing a compelling story and increase their attention to its scientific content. To help some students who lacked basic inquiry skills, we will add an optional, one hour Research 101 workshop. The workshop will give direct instruction on how to use the personal interest keywords to identify pertinent research topics, researchers, and their publications through scholarly search engines. Students will be encouraged first to conduct their own independent research and use the interview only for information not available in primary sources.

Second, students professed unfamiliarity with narratives and integration of scientific information into a story as key difficulties. Students even recommended specific guidance in creative writing. Ironically, all had completed required college courses in composition that, according to the University, explicitly dealt with the types of writing and skills employed in the narratives. In fact, a key argument for the preferred use of narratives is the familiarity of students with written stories (Clopton, 2011). Our research suggests greater familiarity with stories should not be conflated with greater comfort with *writing* stories. Instructors should not assume students are sufficiently competent with creative or rhetorical writing simply because they have had such foundational courses. Probably, without reinforcement in other courses, science students in particular will be minimally equipped and lack the confidence to take on the simultaneous challenges of understanding unfamiliar topics and writing in what they perceive as an unfamiliar format. It is unlikely a science course can dedicate significant attention to rhetorical writing; therefore, the effectiveness of narratives in the sciences will likely require curriculum-wide attention to rhetorical writing.

Third, students lacked meaningful engagement with the narrative assignment. The instructor communicated a rationale for this activity to students through the syllabus and noted student relevance regardless of individual majors and career goals, and the assignment could be tailored to address individual interests and needs for both undergraduate and graduate students. However, students reported the lack of perceived value and relevance of the research narrative for science learning. According to the Self-Determination Theory (Deci & Ryan, 2000), failure to recognize the value of an activity can result in a lack of motivation. Building on this assessment, we added some guiding activities to promote motivation while retaining the constructive parts of the process.

Empirically, students can better internalize the value of the assignment and optimize their attitudes accordingly if we communicate the congruence of this assignment to the overall course goals at the beginning and throughout the course (Reeve, Jang, Hardre, & Omura, 2002). Also, we will add the “keyword activity” where students generate lists of personal interest keywords to use in their research of potential topics. This is intended to help students better understand the relevance of the research narrative to their own expectations of the course. Furthermore, student engagement is enhanced when the learning artifact is aimed at authentic audiences (Gunel, Hand,

& McDermott, 2009; McDermott & Kuhn, 2011). Accordingly, students will have the option to publish their narratives to several science blogs that accept guest pieces.

Student comments revealed additional confusion that challenged our assumptions. Although the instructor provided two professional examples, including one directly related to the course subject matter, students reported these examples as the least useful component. Possibly, students thought that the professional model from *National Geographic* was too long or involved. One possible remedy is to have students critique the professional examples for effective elements related to scientific content and storytelling. A second is to encourage students to identify their own model. Students could analyze different stories to discuss ways to communicate science to a target audience. This would increase the likelihood that students identify an achievable target and maintain a high level of autonomy. For students who experienced difficulty with autonomous self-regulation activities, such as planning for revision, we will add a requirement of a cover letter to the submission of the final draft in which students described how they ultimately addressed peer and instructor feedback and revised their stories.

Students argued for a grading rubric that detailed more specific criteria. Rubrics are guidelines laid out for evaluating students' work on a performance-based task and provide both the instructor and students with a mutual understanding of what is expected. Menu-driven rubrics can be detrimental in writing assignments (Wilson, 2007). Kohn (2006) observed that overly prescriptive rubrics cause students to think less deeply, avoid taking risks, and lose interest in learning. Within the confines of a rubric, students can self-direct their efforts and reflect on their progress (Luft, 1999); therefore, we intentionally kept the rubric general to allow creative freedom. However, students found it helpful and instructive to receive specific feedback on ideas not evident in their writing (e.g., had any work been done on boat strikes and wildlife?), which enabled them to elaborate on the events of conducting research and further develop characters and scenes.

While students expressed discomfort or dissatisfaction with certain tasks, we would recommend restraint by instructors in accommodating their wishes at the expense of learning. If writing is a way of thinking and learning, then we recognize the value of having them write lies in many of the struggles students reported. Students learn as they navigate away from uncertainty, and the job of an instructor is not to create a smooth road to an easy grade but to create a challenging road that pushes students outside their comfort zones and encourages them to formulate and defend their own ideas. The instructor’s endeavor is to distinguish challenges that contribute to the value of researching and writing a story from those that potentially detract from the activity’s value.

Implications

SCLEs involve cultivating autonomous self-reliance while providing guidance. Instructors use several strategies to support students’ navigation and complete their projects autonomously. First, instructors need to provide a compelling rationale as to why a project is designed and how it supports individual learning. Having students understand their individual responsibility and potential benefits can increase their engagement (Reeve et al., 2004). Previous research showed that students who received the rationale increased autonomous motivation, behavioral engagement, and conceptual learning (Jang, 2008). Next, instructors need to ensure opportunities for students to make individually relevant and interesting choices as they integrate them into classroom activities. Research has shown when students work on personally meaningful projects, they become more invested in the outcome (Patall, Cooper, & Wynn, 2010). Finally, autonomy support means providing key parameters and structures through which students gauge their roles competently. When autonomy support is complemented by structured guidance, students better direct and manage an autonomous task (Jang, Reeve, & Deci, 2010), ultimately improving learning outcomes (Su & Reeve, 2011).

Limitations

This study was conducted once in a single class when the assignment was offered for the first time. While we incorporated the triangulation measures (e.g, diversified methods) to assure validity and reliability (Creswell, 2013), the generalization of the findings is limited due in part to the small number of participants (N=19). This study was the first attempt to formatively evaluate and redesign the use of narratives in a science course. As we iteratively implement, evaluate, and refine, we can further inform implications of story writing in the sciences and recommend design principles for applications in broader settings beyond postsecondary sciences (The Design Research Collective, 2003).

Conclusion

Engaging students in reading and writing stories about science is proposed as an effective tool for teaching the processes of science. In addition, writing stories affords students autonomy to link course content to topics of personal interests to them and enables them to adequately understand concepts to communicate with a lay audience. The benefits of using science narratives are premised on the assumption that students are more comfortable with writing rhetorical stories. Our study described student experiences while producing science narratives for a postsecondary biology course. Our study revealed that despite having composition courses, science students expressed greater discomfort writing narratives. Tasks related to interweaving scientific information into a story and translating scientific concepts for a lay audience arguably have high academic value (Prain & Hand, 2006).

Instructors must be cautious when assuming students' comfort and skill sets for completing the assignment as evidenced in such difficulties as recognizing the academic value of story writing and identifying primary resources. At the same time, curriculum-wide attention to rhetorical writing can lessen the pressure on science instructors in assisting students with story development and help them focus on teaching the process of science using narratives. Assessing student preparedness and scaffolding will likely be essential to the effective use of narratives and other writing formats in science learning.

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CHAPTER 4

THE INFLUENCE OF AUTONOMY, SCAFFOLDING, AND AUDIENCE ON ENGAGEMENT AND PERFORMANCE [3]

[3] Lee, E., Hannafin, M. J., & Maerz, J. C. To be submitted to *Educational Technology Research and Development.*

Abstract

Autonomy, scaffolding, and intended audience are assumed to be critical to engaging students in independent inquiry. This study examined the influence of autonomy, scaffolding, and audience in engagement and performance. Using student-centered learning as a framework and informed by self-determination theory, constructivism, and constructionism, college students were scaffolded to write an original narrative appropriate for the general public while receiving autonomy support. Mixed methods included student interviews, participant observations, and document analysis as well as pre- and post-survey to assess intrinsic motivation, level of engagement, and autonomy support. Findings indicated that the level of engagement (competence, effort, and value) had a significant influence on performance. Autonomy support was facilitated by providing rationale, flexibility, and goal setting opportunities to make projects personally meaningful to students. Scaffolding proved essential for guiding independent inquiry involving both processes of science and writing narratives. Students who chose to publish narratives publicly demonstrated both higher engagement and performance. Promoting dialogue between students and audiences beyond publication further extended learning. Implications for supporting autonomy and scaffolding in a student-centered, constructionist environment are discussed.

Keywords: Student-centered learning, engagement, scaffolding, design research, self-determination theory

Introduction

In student-centered learning environments (SCLEs), students assume increased autonomy and responsibility for their learning (Land, Hannafin, & Oliver, 2012). While external goals may be imposed, students determine the process in which they pursue the goals. Students make decisions about what, how, when, and whether to proceed based on their emergent understanding; determine which tools and resources are useful and apply them to solve a problem; keep track of findings; monitor progress; and reflect on what is being learned (Hannafin, Hill, Land, & Lee, 2014). Rather than promoting compliant understanding based on external expectations (cf. McCaslin & Good, 1992), students are presumed to cultivate deeper understanding, hone personal strategies, plan and pursue individual goals, formulate questions, make inferences, integrate new knowledge with existing knowledge, and refine and reorganize their thinking (Bransford, Brown, & Cocking, 2000).

This study reports design research iterations to examine and refine learning strategies to increase individual responsibility for learning while learning the processes of science and authoring a research narrative. By supporting collaborations involving both peers and the course instructor in the spirit of design-based research, scaffolding activities were designed and incorporated within a college-level science course. Several factors are believed to enhance engagement and inquiry—autonomy, scaffolding, and audience were incorporated and evaluated. The intent was to generate evidence indicating factors that influence student engagement in an autonomous and non-traditional instructional activity. This study is approved by IRB. The consent form is found in Appendix A.

Theoretical Framework

Self-Determination Theory

Self-Determination Theory (SDT) suggests that intrinsically motivated, autonomous behaviors help students to engage in deep, individual, meaningful processing (Ryan & Deci, 2000). Students who pursue intrinsic goals tend to engage their learning tasks more actively than those who pursue primarily external affirmation, recognition by instructors, or avoidance of negative consequences (Meece, Blumenfeld, & Hoyle, 1988). When students' basic psychological needs are satisfied in the course, students will be more likely to value and persist in the course (Ryan & Deci, 2000). Students feeling of autonomy, competence, and relatedness influence volition, motivation, and engagement and enhance performance, persistence, and creativity (Deci & Ryan, 2000).

During SCLEs where students solve complex problems that require creativity and flexibility, autonomous motivation presumes to enhance performance more than externally-based performance goals alone. When students make autonomous decisions, they assume greater responsibility for directing their learning, become more personally engaged, and deepen their understanding. Theoretically, therefore, SCLEs provide opportunities to cultivate individual responsibility for engaging learning opportunities, which enhances academic performance as well as student autonomy.

Constructivism

Constructivists suggest that learner, context, knowledge and understanding are connected and interdependent. Constructivist learning involves iterative processes of discovery as students use their own mind to obtain knowledge for themselves and "rearranging or transforming evidence" to assemble "additional new insights" (Bruner, 1961, p. 22). Individuals do not receive and process information passively, but they actively construct knowledge and skills and reorganize their understanding via interactions with their environment as well as other encounters and past experiences (Jonassen, 1999).

During SCLEs, students are situated in an active, authentic context that facilitates their sense-making process. Rather than directing students to discover what is “out there,” the instructor generally guides students to pursue individually relevant meaning. To support discovery, students experience diverse models and feedback on their actions, which subsequently promote interaction between the student and others. Students interact reciprocally with peers and more knowledgeable others to support richer understanding than is possible individually (Vygotsky, 1978). Students communicate and make their thoughts and ideas explicit; they examine both their individual perception and others’ views and react accordingly.

Constructionism

Constructionists argue for the importance of producing external and shareable artifacts (Harel & Papert, 1991): “constructivist processes are more evident when students collaborate to produce and share representations of their understanding of the world” (Jonassen, Myers, & McKillop, 1996, p. 94). Students become designers whose artifacts reflect complex cognitive negotiations with external constraints; in effect, their designed and created products represent socially shared cognitive representations (Jonassen, Myers, & McKillop, 1996). Activities involving making, building, programming, teaching, and consulting provide rich contexts for learning (Harel & Papert, 1991). Shareable artifacts reflect and embody student understanding; failure, reflection, and iterative revisions refine understanding of concepts and associated skills and practices (Kolodner et al., 2003).

Constructionists also suggest that learning occurs both while designing as well as through sharing. Constructionist environments create a culture and community as students share one another's creations and gain a deeper understanding of other people's perspectives about the product and ideas related to the product (Evard, 1996). Such environments promote learning by doing as well as learning by thinking and discussing what you do (Kafai & Resnick, 1996). In middle-school science inquiry-based construction activities, for example, students both justified their design decisions and explained the mechanics of their products (Kolodner et al., 2003). Students become intellectually engaged and personally invested when working on personally meaningful activities and projects (Kafai & Resnick, 1996). This enthusiasm influences both their attitudes toward the subject matter as well as their performance (Harel & Papert, 1991). Students become more cognitively and emotionally engaged as they employ resources in a social context and design and refine both their understanding and artifact. Accordingly, a student's responsibility for individual understanding increases as associated ownership of both learning processes and the products increase.

Student-Centered Science Learning

Science instructors increasingly adopt student-centered learning. Students engage in inquiry processes to construct or reconstruct their understanding (Kim, Hannafin, & Bryan, 2007; Walczyk & Ramsey, 2003). For example, Web-based Inquiry Science Environment (WISE) was designed to promote cohesive, coherent, and thoughtful accounts of complex science concepts and processes through inquiry (Linn, Clark, & Slotta, 2003). Davis and Linn (2000) reported that secondary students who monitored their learning progress and identified connections between ideas demonstrated improved integrated understanding of science phenomena compared to students who attended only to the inquiry process. Likewise, in postsecondary organic chemistry courses, students engaged in small group, student-centered, problem solving with peer support to promote active engagement; autonomy support directly influenced course performance and completion of students who were initially not motivated to enroll in the course (Black & Deci, 2000).

Science education advocates suggest that helping students become effective communicators of science help both the author and audience improve science understanding (Gunel, Hand, & McDermott, 2009). Writing has been widely recognized as a powerful student-centered learning tool to stimulate thinking and enhance science learning (MacKenzie & Gardner, 2006; Madigan, 1987; McDermott & Kuhn, 2011; Moore, 1994; Tessier, 2006). Writing involves reflection on and expressions of understanding in meaningful organizations (Hayes & Flower, 1986); effective writing promotes reexamination of flaws to facilitate revision and reorganization, which may subsequently relate to additional research or be discarded (Alamargot & Chanquoy, 2001; Hayes, 1996). Prain (2006) argued that teachers need to encourage students to write in diverse forms for different purposes since diversified writing helps students translate scientific and technical terms into everyday language, connect emerging to existing knowledge, and clarify networks of concepts in science topics.

National Science Education Standards indicate that students learn more than basic scientific facts and theories; they also learn the methods and processes of scientific investigation (National Research Council, 1996). Narrative has been particularly recognized as important to understanding the process of science and the human endeavor in conducting scientific research (Clopton, 2011; Robinson & Hawpe, 1986; Wilson, 2001). Martin and Brouwer (1991) assert that narratives facilitated personal engagement and full exploration of meaning thereby revealing subtle ways in which scientists navigate the process of science. In the United Kingdom, conceptual chemistry was presented as a narrative situated in a context that demonstrated coherent cause and effect and depth of meaning (Burton, 1994). Secondary students responded positively to narrative; narrative proved as or more effective as presenting the same concepts via traditional, context-free text (Schwartz, 2006). Writing stories improved middle school students' familiarity with science issues, understanding of scientific concepts, and interest in science (Ritchie, Tomas, &Tones, 2010). In this study, writing of research narratives, therefore, represents a student-centered constructionist learning.

Method

Background

This iteration of an ongoing study took place in an upper level undergraduate and graduate Organismal Biology course, open to both majors and non-majors at a large southeastern U.S. university. The class consisted of two weekly 90-minute lectures and a weekly three-hour lab for both majors and non-majors. This course was 4-credit hour course, one more credit hour than a typical undergraduate course. The course instructor, Dr. Kennan Hertz (all names used in the paper are pseudonyms) previously received an award for teaching excellence and strived to promote student-centered learning. Student-centered learning approaches were promoted in the scope of the course, not necessarily curriculum- or university-wide. Besides the research narrative, several student-centered assignments and activities were incorporated, including an instructional lab in which small groups teach peers and a pond inventory with which student groups document and maintain an inventory of species observed in the assigned field.

The instructor initially incorporated a research narrative in Spring 2012. Students individually identified and interviewed a recognized scientist who specializes in reptiles and amphibians, and subsequently compose a narrative keyed to an individual research project. The syllabus (Appendix B) states three objectives of the research narrative:

> *First, it is an opportunity for each student to familiarize themselves with a line of research and the people involved in that research. Second, it is a process by which some of you may identify prospective graduate mentors should you be interested in graduate studies in herpetology. Finally, there is mounting evidence that narratives are an excellent way to build an understanding of science as a process. (Syllabus, 2012)*

Hence, the research narrative project was designed to promote understanding of the science process by writing a story about a research project. Students set the scene, developed characters, and used other elements of good storytelling such as rising action, climax, and falling action. When writing the research narrative, students were to communicate specialized scientific information to a lay audience, which involved translating scientific concepts to everyday language. Initial scaffolds provided a detailed description of the assignment, project rationales, sample interview questions, anticipated challenges, a list of potential interviewees, incremental milestones (first draft, revisions, and final drafts), an assessment rubric (Appendix C), examples of professional stories from National Geographic, peer review (Appendix D), self-critique (Appendix E) and instructor feedback on early drafts. The course instructor further supported autonomy via a student-centered approach in which students identified and interacted with the scientists, investigated their work, and presented their narratives.

The course instructor and researchers jointly collaborated and evaluated the design and impact of the research narrative project. Both quantitative and qualitative data were collected with regard to students' perspectives on the research narrative project, their self-reported motivation, and perceptions of the instructor's autonomy support. This preliminary study served as a needs assessment to identify areas where students reported or demonstrated difficulty and to identify possible improvements (Lee & Maerz, in review; Chapter 3).

Preliminary Findings & Design Implications

Students lacked meaningful engagement with the narrative assignment. According to the Self-Determination Theory (Ryan & Deci, 2006), failure to recognize the value of an activity influences both participation and investment in the assignment. The instructor communicated a rationale for this to both undergraduate and graduate students, noting relevance regardless of individual majors and career goals, and tailored the assignment to support individual interests and needs. Student response evidence, however, indicated both lack of perceived value and relevance for science learning.

Next, a discrepancy was evident between the instructor's intended learning goals and observed student accomplishment. The primary objective was for students to recognize scientific processes involving human endeavors; however, students misunderstood or misinterpreted the instructor's intention: public outreach, making connections to current research and researchers, and personal engagement with the field. A similar misalignment was observed in Tao's (2003) study, in which secondary students interpreted stories about scientific discovery (e.g., The story of penicillin) in idiosyncratic ways focusing their attention selectively on certain aspects of the stories.

To address the issues identified in the needs assessment and support meaningful engagement and learning the process of science, we applied a theoretical design framework: *Own it, Learn it, & Share it* (OLSi) (see Figure 4.1). Factors believed to enhance engagement—autonomy support, scaffolding, and audiences—are integrated into the design of the OLSi. Lee and Hannafin (Chapter 2) provide a detailed description of the OLSi framework; this paper briefly introduces the key concepts related to this study.

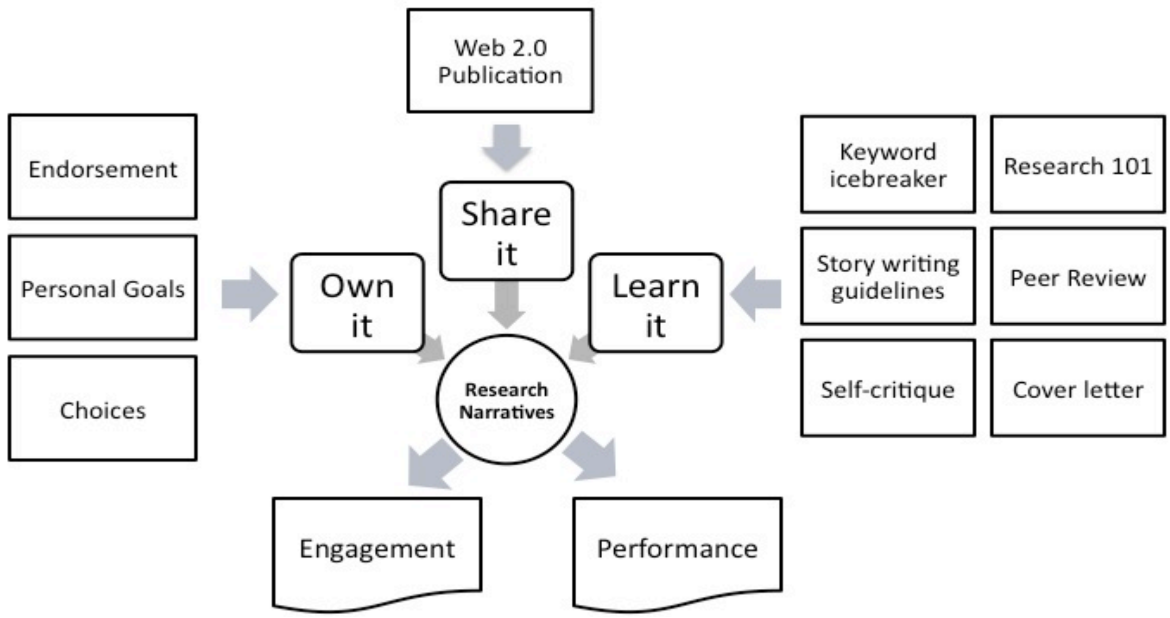


Figure 4.1. Relationship among key variables and scaffolding activities

Own it is designed to increase students' perceived autonomy and promote ownership as suggested in Self-Determination Theory. According to Ryan and Deci (2000), autonomous behaviors emanate from intrinsic motivation and reflect interest or personal importance and, in turn, promote deep, individual, meaningful processing. SDT suggests that perceived autonomy enhances engagement, performance, persistence, and creativity (Deci & Ryan, 2000). SCLE's social contexts are designed to promote intrinsic motivation and support autonomy. In effect, intrinsically motivated, autonomous students assume the power and control to determine their learning goals, decisions, and actions; consequently they become accountable for the outcomes of their goals, decisions, and actions. Perceived autonomy can be further enhanced by providing: (a) rationales for why the research narrative is required to facilitate endorsement of externally imposed activity (Reeve, Jang, Hardre, & Omura, 2002), (b) opportunities to set specific personal goals (Acee, Cho, Kim, & Weinstein, 2012; Hidi & Harackiewicz, 2000), and (c) choices to attend to personal interests (Flowerday & Schraw, 2000; Patall & Wynn, 2010).

Learn it is designed to scaffold conceptual, strategic, metacognitive, and procedural support to guide inquiries advocated by constructivists (Hannafin, Land, & Oliver, 1999). In SCLEs, scaffolding assists students to participate meaningfully by supporting efforts to identify relevant goals, pursue and monitor progress toward those goals, reconcile differences between existing understanding and concepts yet to be learned, and construct and refine artifacts (Hannafin, Hannafin & Gabbitas, 2009). Scaffolding may involve explicit directions at the initiation of the activity and support for the selection and use of tools and resources. Scaffolding is provided in the form of expert modeling (Pedersen & Liu, 2002), question prompts, peer feedback (Ge & Land, 2003), and step-by-step check points to improve knowledge integration (Chen & Bradshaw, 2007), higher-order thinking (Kim & Ryu, 2013), problem solving (Clarebout & Elen, 2006), self-regulation (Azevedo, 2005), active discussion (Huang, Wu, Chen, 2012), and peer collaboration (Roschelle et al., 2010).

Share it is designed to enhance student engagement by presenting and sharing products with real world audiences. Constructionists argue that learning is optimized when students design and produce tangible artifacts to embody understanding and to share with others. Sharing artifacts facilitates personal reflection and social interaction (Harel & Papert, 1991). Writing researchers have argued that publishing student papers to peers reinforce them to put more effort because they are made aware of readership (Cohen & Riel, 1989). Students need to communicate their research narratives to the general public with varied domain knowledge. As students share their writing and exchange reviews and perspectives, they develop stronger personal investments in their learning and outcome (Lundstrom & Baker, 2009).

Participants

Participants included 22 of 24 students enrolled in the course (18 upper classmen and 4 first-year graduate students; 14 female and 8 male); 20 also participated in the follow-up interview. The mean age of participants was 22. About 50% had taken at least one research method course but nearly the same percentage (47%) had not yet taken an educational measurement class. However, all students rated their familiarity with the general process of conducting scientific research from somewhat familiar to very familiar. All undergraduates were required to complete compulsory English composition courses in their freshmen year.

Data Sources

DBR studies routinely incorporate mixed methods in the research process and result in data from multiple sources, which serves to enhance the credibility of findings (Wang & Hannafin, 2005). This iteration employed a mixed methods design incorporating a variety of quantitative and qualitative measures (see Table 4.1) to examine the multifaceted independent and dependent variables. The quantitative study consisted of self-determination questionnaires to measure engagement and Likert scale questions asking for students' experiences of scaffolding activities and scores on the first and final drafts. Qualitative analyses consisting of student interviews, participant observation, and document analysis of syllabus, research narrative instructions and rubrics, and peer review and self-critique templates added depth and anecdotal evidence to findings from quantitative measures.

Presurvey: The presurvey served two purposes: (1) solicited demographic information of the participants; and (2) identified participant's initial motivation to enroll in this course as well as their attitude toward the research narrative using Learning Self-Regulation Questionnaires (*LSRQ*). LSRQ assesses the degree to which an individual's motivation for a particular activity tends to be relatively autonomous versus relatively controlled. LSRQ was used twice in January and April to assess changes in intrinsic motivation toward the overall course through the end of the semester. In past studies, the alpha reliabilities for these two subscales have been approximately 0.75 for controlled regulation and 0.80 for autonomous regulation. Relative Autonomy Index (RAI) was calculated by subtracting the controlled subscale score from the autonomous subscale score from LSRQ.

Table 4.1. *Mixed Methods Data Sources*

Quantitative		Qualitative	
Sources	Instruments/ Questions	Sources	Instruments/ Questions
Presurvey (Appendix F)	Learning Self-Regulation Questionnaire Personal Goals Endorsement	Student interview (Appendix H)	Their approach to research narrative Relationship with the researcher Gains Difficulty
Post-survey (Appendix G)	Self-Regulation Questionnaire Intrinsic Motivation Inventory Learning Climate Questionnaire Self-report on understanding of research method Personal goal achievement Helpful resources Audience choice	Document analysis Participant observations (Appendix M)	Assignment instruction (Appendix I) Rubric (Appendix J) Peer review template (Appendix K) Self-critique template (Appendix L) Introduction Keyword icebreaker (Appendix N) Research 101 Peer Review
Scores	First draft total Final draft total		

Postsurvey: The post survey assessed the following: (1) student's subjective experience of their completion of the research narrative and suggestion for improvements in multiple choice questions, Likert Scale ratings, open-ended questions; and (2) student's perceived autonomy support using Learning Climate Questionnaire and level of engagement using Intrinsic Motivation Inventory (IMI).

- *LCQ*: The Learning Climate Questionnaire assessed student perceptions of the degree to which the course instructor supported individual autonomy versus emphasized external control. The *LCQ* has a single underlying factor with the alpha coefficient of internal consistency above 0.90 (Williams & Deci, 1996).
- *IMI*: The *IMI* jointly assesses students' levels of engagement in the areas of enjoyment/ interest, effort, perceived choice, value/usefulness, perceived competence, and relatedness with *the* researcher while they are performing the research narrative project. McAuley, Duncan, and Tammen (1987) found strong s*upport for its validity.*

Student interviews: The researcher conducted 30-minute, semi-structured, one-on-one interviews with 20 participants at the end of the course. From the 20, six were selected for in-depth analysis: three whose RAI increased (namely, motivated group) and three whose RAI decreased (namely, demotivated group). Student interviews yielded qualitative data on participant experience while completing the research narrative project. For triangulation purposes, interview topics paralleled the major concepts of the survey instruments.

Document analysis: The syllabus, assignment description, rubric, self-critique template were used to analyze the instructor's autonomy support through written communication.

Participant observations: Participant observations yielded data on the instructor autonomy style and teacher and peer scaffolding in the classroom. Participant observation protocol was roughly structured to accommodate my spontaneous observation and discovery. Three observations were conducted. First, I observed the participants on the first day when the assignment was first introduced, and keyword icebreaker was conducted. The foci of observation were how the instructor communicates the significance of the assignment, its alignment with the overall course goal, and the expected outcomes. The introduction of the class also displayed how the instructor delivers his autonomy supportive style. Second, I observed all three days of the Research 101 workshop. The focus was on how the instructor used the procedural scaffolding to walk students through the inquiry and interview process. Third, I observed the peer review session. The observation focused on how the instructor facilitated the peer review in an autonomy supportive manner and students interacted among peers to exchange verbal reviews.

Variables and Analyses

Data sources provided complementary indicators for analyses (See Appendix O for data analysis matrix). Table 4.2 displays the independent and dependent variables followed by descriptions of each.

Table 4.2. *Independent and Dependent Variables*

Independent variables	Dependent variables
Change in motivation	Engagement
Autonomy	Performance
Scaffolding	Improvement
Audience	

Change in motivation. The LSRQ was used to assess changes in intrinsic motivation toward the overall course through the end of the semester by administering on the first day of course in January and again on the last day of lab in April. RAI changes from the presurvey to postsurvey provided indicators of motivation changes.

Autonomy. Perceived autonomy was analyzed using both quantitative and qualitative measures. Quantitative measures included perceived autonomy support (PAS) assessed by a Learning Climate Questionnaire (LCQ) about the degree to which the course instructor is autonomy supportive versus controlling. PAS was calculated for each participant and correlated against other engagement variables. LCQ has a single underlying factor with the alpha coefficient of internal consistency above 0.90 (Williams & Deci, 1996). Intrinsic Motivation Inventory (IMI) assesses students' autonomous motivation in the six respective areas of enjoyment, effort, perceived choice, value, perceived competence, and relatedness with the researcher while they are performing the research narrative project. In addition, students' initial personal goals from presurvey and achieved personal goals from post survey were compared. Students' endorsement from presurvey were counted and compared with their engagement and performance.

Scaffolding. The usefulness of scaffolding activities were rank ordered using the postsurvey responses and equated with participant observations and student interviews to analyze students' perceptions of each scaffold. The qualitative data from the student interviews and participant observation field notes, and document analyses were transcribed. Transcripts and field notes were combined and analyzed using thematic analysis methods, such as constant comparisons, initial coding, focused coding, and memo-writing to generate subcategories and themes within and across the participants in the constructionist perspective (Corbin & Strauss, 2008; Prasad, 2005). Data were coded into conceptual clustered matrices to categorize key themes (See Appendix P for examples of category, clusters, and codes used).

Audience. Students were provided audience options for their research narratives within two weeks of starting the course. They voluntarily chose from no audience, peer audience, and real world audience. To determine the effect of audience on the engagement and performance, we used one-way between subject ANOVA.

Engagement. Level of engagement while completing the research narratives was measured using IMI. Engagement combines enjoyment, effort, perceived choice, value, perceived competence, and relatedness with the scientist while they performed the research narrative project. Due to the limited number of students, principal component analysis (PCA) was used in an attempt to reduce the dimensionality of IMI's six variables while retaining possible variations within the data set (Jolliffe, 2002). This reduction is achieved by transforming to a new set of variables, the principal components, which are ordered so that the first few retain most of the variation present in all of the original six variables.

Improvement. The absolute difference in scores from the first narrative to the final research narrative were calculated and used to indicate the improvement in learning the process of science as influenced by the OLSi scaffolding. Nine of 22 students revised and resubmitted their narratives and therefore had improved scores.

Performance. Students' final scores on the research narratives were used to indicate the performance on the research narrative not taking account of the change of scores from the first and final drafts.

Procedures

The research narrative was organized in three sequential phases: *Own it* (developing autonomous motivation), *Learn it* (student-centered inquiry), and *Share it* (writing for a real world audience). Figure 4.2 depicts the OLSi framework, timeline, procedures and associated scaffolding activities. (Appendix Q displays data collection activities and instruments of each phase aligned with its objectives, activities, resources, and student deliverables. This appendix is available as part of dissertation but excluded from the journal submission.) Detailed description of materials and implementation procedures are presented for each of the three major constructs of engagement.

Introduction and Keyword Icebreaker. On the first day of class, I unobtrusively observed the morning lecture to see how the instructor introduces the course goal. The instructor gave an overview of Herpetology, and emphasized the course's autonomous nature. In addition, the instructor facilitated "Keyword" activity in which students identify three keywords that represent their interests. Students were expected to use the personal keywords to search for possible interview candidates.

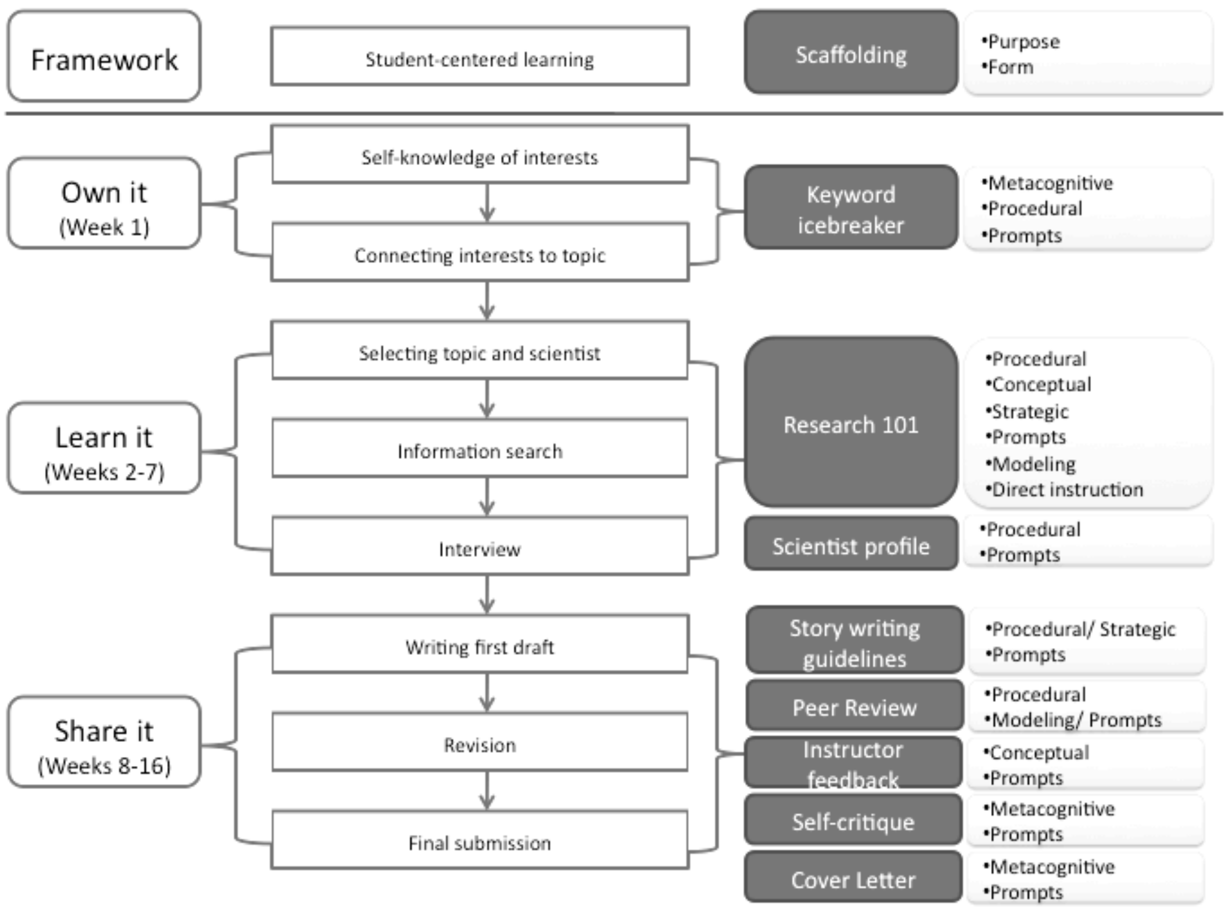


Figure 4.2. Procedures

Participant Recruitment and Presurvey. On the same afternoon during the lab, the instructor gave a thorough overview of the research narrative project and associated scaffolding activities. Students were provided details of the assignment requirements as well as the instructor's intent in requiring this assignment. At the end of the lab, the instructor introduced the first author as an observer and a researcher for the class. The first author discussed the objectives of the research and associated information per IRB requirement. Subsequently, presurvey and consent forms were distributed to students. Students chose one, two, or all of the participation options: taking surveys, participating in interview, and giving me access to grades and assignment submissions. All enrolled students volunteered to participate in the surveys. At the end, participating students returned the signed consent form and completed presurvey to the researcher.

Own it. *Own it* questionnaire was embedded in the presurvey and included questions about the student's endorsement and personal goals for the research narrative activity (i.e., the syllabus states three objectives for the research narrative project. Rank each objective in the order of importance to me personally; what would be my personal goal to achieve from this activity?). Students were asked again during the post survey which goals they have accomplished (i.e., To what extent do I feel I have achieved each of the following through the research narrative project on a scale of 1 -7?). Students gave a Likert scale rating of the value of the activity (i.e., "The research narrative project sounds like an important learning activity to me"). These questions were entered into SPSS for statistical analyses.

Audience choice. Two weeks later during the lab, students gave their choice about whether to publish their finished narrative to either a peer or real world audience or to submit only to the instructor. Student audience choice were entered into SPSS and yielded categorical data.

Learn it. Learn it was designed to guide student-centered inquiries on learning the process of science while investigating the research topics and interviewing with the scientist through Research 101 workshops and the scientist profile. Research 101 workshops were offered on a voluntary basis in the lab from 5-6 pm on Tuesday, Wednesday, and Thursday of Week 2. 16 students chose to attend one of the three workshops and received extra credit points. Research 101 workshops were offered the combination of procedural, conceptual, strategic scaffolding using question prompts, expert modeling, and direct instruction. Research 101 helped students answer following questions: "how do I find a researcher whose research match my interest?" and "how do I find peer-reviewed articles that are written by the researcher?" The instructor provided modeling for students' inquiry of identifying potential researchers and their scholarly journals on Google Scholar and understanding the science processes from a science report (research paper). The instructor asked students how students would contact potential researchers and gave some strategic advice on what to include in the introduction email, what questions to ask, and how to use their answers for writing their story. He also discussed the elements of effective story writing such as arc and character development. At the end, students completed a brief survey about the helpfulness of the workshop and listed remaining questions. By the following week, students posted the brief profile of the scientist they chose to interview on the course website.

Share it. *Share it* assisted with writing narratives for an audience. Two weeks before the first draft was due, story writing guidelines (Appendix R) were posted on the course website and on the course Facebook page. On week 7, before spring break, students submitted the first draft. One week after the first draft was due, students participated in a mandatory peer review session in a real time during the lab for two hours. The peer review session was similar to the last offering in its purpose and format. The instructor first introduced the purposes and attributes of an effective peer review. Then, the instructor and the TAs modeled effective peer reviews by providing constructive feedback and monitoring the student group's peer feedback. Students played the role of professional peer reviewer. Students were given the peer review template, which prompted reviewers to state the author's strengths and weaknesses followed by supporting evidence and ideas for improvements. After the peer review session, students voluntarily completed and submitted the self-critique from for bonus points, Students also received the instructor's written feedback, optionally revised, and submitted the final draft accompanied with a cover letter for a grade.

Postsurvey and Student Interviews. At the end of the semester, during the final lab, we administered the postsurvey. Overall, 22 students completed the survey. After the due date of the research narrative, we conducted 30 minute interviews, individually, with 20 students. Students received extra credit for their participation.

Results and Discussion

Change in motivation toward the course

Relative autonomy index (RAI) was calculated from the difference between the scores of autonomous regulation and controlled regulation measured in LSRQ to indicate individual students' motivation toward the course was intrinsic versus extrinsic. Both pre and post RAI results indicated that student motivation toward the course was more akin to intrinsic than extrinsic motivation (pre: 1.94, post: 1.48). However, Pre-Post RAI comparisons revealed that overall intrinsic motivation decreased during the semester.

A clear distinction emerged between students whose intrinsic motivation noticeably increased and those whose intrinsic motivation decreased. Three students whose RAI were most increased were selected to arbitrarily form the motivated group and three students whose RAI were most decreased formed the demotivated group. Both groups differed in their engagement with the course and research narratives as well as their perceived autonomy support from the instructor. Table 4.3 summarizes the contrast between the motivated and demotivated groups and the individual account of engagement variables.

Table 4.3. *Motivated Group vs. Demotivated Group*

	Motivated Group			Demotivated Group		
Pseudonym	Dave	Sophie	Austin	Katie	Gretchen	MaryKate
RAI	1.2	0.8	0.6	-1.9	-1.6	-1.4
PAS	6.6	5.4	7.0	2.6	3.8	3.4
Engagement	0.58	0.99	1.18	0.87	1.59	-1.0
Improvement	5	7	10	0	0	0
Performance	87	98	84	78	83	79

Note: Pseudonyms used in lieu of actual names; they reflect gender.

Motivated Group

The motivated group's (Dave, Sophie, and Austin) motivation toward the course was increased during the semester (1.2, 0.8, and 0.6 respectively). In fact, it remained consistently at the level of "identified" which means that their motivation toward the course was autonomous rather than controlled. Also, the motivated group's perceived autonomy support from the instructor was higher than the class average of 5, in addition to their positive report of their relationship with the instructor. Also, the motivated groups revised their first drafts and increased final scores and demonstrated a positive attitude toward multi dimensions of the research narratives including value and enjoyment.

> *You can't always depend on your teachers to tell you exactly what to do. I know I've been complaining about not having like the outlines and stuff that I'd need*

> *but it's necessary especially in this stage of our lives, we're in college, we're not in high school anymore … So, it definitely helps you learn how to do more research and how to depend on yourself, I guess. (Sophie)*

Demotivated Group

In contrast, the RAI scores of the demotivated group (Katie, Gretchen, and MaryKate) decreased (-1.9, -1.6, and -1.4 respectively) and their motivation toward the course was controlled rather than autonomous. Their PAS was below the class mean and their comments about their relationship with the instructor were negative. With the exception of Gretchen, the demotivated group's engagement score was low indicating that their engagement with the research narrative was low. The three individuals did not revise their first draft for score to increase their score, with the exception of Gretchen who later revised her narrative and published it for the real world audience after the course ended. Each individual accounted their cause of falling out of class.

> *I feel like I am very much more grades driven in this course, which is a shame. … I want to do it well because I like doing things well because I find it personally satisfying. Courses like this, I don't want to particularly put efforts in. I don't see the point. …. I never had a class so thoroughly turning me off something I liked so much. (Mary Kate)*

Our analysis subsequently examined the entire class's engagement in and learning of the process of science and highlighted the contrast between the motivated and demotivated groups.

Autonomous motivation, engagement, improvement, and performance

Autonomous motivation was measured by IMI and LCQ. Table 4.4 shows the correlation among key engagement variables from IMI and LCQ that represent the interrelatedness of variables. Perceived enjoyment, value, choice, competence, effort, and relatedness influenced engagement with the research narratives. Enjoyment, value, and effort directly influenced performance. Enjoyment correlated with value, choice, and competence, which can be interpreted to mean that students who enjoyed the research narratives also perceived value, choice, and competence in the research narratives. However, enjoyment did not correlate with effort and relatedness which means that students who enjoyed the research narrative did not necessarily invest more effort or related with the scientist, and perceived autonomy support from the instructor. Students who did not enjoy or value the assignment reported a variety of reasons including lack of competence in and perceived relevance of story writing in learning science and concerns over "bothering" busy scientists to gain a "human" perspective on conducting research.

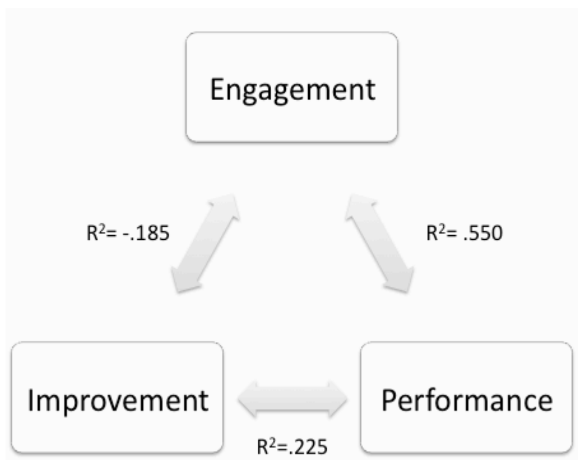


Figure 4.3. Correlation among engagement, improvement, and performance

As depicted in Figure 4.3, engagement was moderately correlated with performance ($p<.01$); however, engagement and improvement were also slightly, though not statistically negatively, correlated. These correlations indicate that engagement influenced students' performance but not necessarily their revision efforts for the revision of narratives and subsequent score changes. Improvement represents changes in learning the process of science from the initial draft to the final submission. Initial scaffolds including Keywords Icebreaker, Research 101, and story writing guidelines may have been adequate to write the initial draft, and students' understanding of the process of science was demonstrated in the initial drafts.

Subsequent scaffolds including peer review, self-critique, and cover letter were implemented after the submission of the first draft may not have influenced students' revision efforts for improvement and learning the process of science.

Table 4.4. *Correlation Among Variables*

	enjoy.	value	choice	comp.	effort	relate.	pas	engag.	impro.
value	.908**								
choice	.672**	.659**							
competence	.628**	.537**	.478*						
effort	.319	.280	.377	.566**					
relatedness	.363	.310	.391	.035	.315				
pas	.268	.270	.178	-.108	-.056	.488*			
engagement***	.909**	.871**	.818**	.746**	.592**	.474*	.219		
improvement	-.175	-.057	-.202	.009	-.078	-.389	.138	-.185	
performance	.526*	.555**	.260	.371	.483*	.265	.172	.550**	.225

*** Engagement variable is the transformed principal component derived from enjoyment, effort, choice, value, competence, and relatedness by principal component analysis

** Significant at the 0.01 level (2-tailed).

* Significant at the 0.05 level (2-tailed).

All motivated students revised their drafts and improved their performance while students in the demotivated group did not. A total of 13 students chose not to revise their drafts but the reasons were not evident. We inferred from student interviews that the demotivated students either did not perceive value in spending additional time and effort on their narratives, or they were initially satisfied with their first draft and did not feel the need to revise, or the perceived workload was heavy.

Autonomy Support

Autonomy support involves relinquishing control to students while identifying, nurturing, and building students' inner motivational resources (Reeve & Jang, 2006). Throughout the course, the instructor emphasized student autonomy and responsibility. At the first class meeting when the research narrative was introduced, the instructor displayed a National Geographic example. He then provided rationales for requiring the research narratives both verbally and in writing (in the syllabus) and encouraged students to personalize the assignment to their individual interests.

> *"Typical stories show a process. Narratives are organized or fleshed out to highlight a process. These research narratives show the process of conducting research. Writing a research narrative is an excellent way to deeply engaged in understanding the process of conducting research. That is the primary but not as attractive focus. What is appealing about the research narrative is that you can customize this assignment to be what you are interested in.*
>
> *Not everyone in this class aspires to be herpetologists but more people are interested in science, and most of you are trying to figure out. In this research narrative, you have an opportunity to make this course relevant to you by addressing your interests and really make it interesting. You have a freedom to make it relevant to you. You also have the responsibility to do the work. There are several milestones that would help you. We will check in with you throughout the process and see if you need help." (Observation field note during lecture on the first day of class, January 8, 2013)*

Overall, the students' perceived autonomy support (PAS) from the instructor measured by the LCQ was 5.0, which is above median and indicates that the students perceived that the instructor to be supportive of their autonomy by providing choice and respecting individual interests and needs. However, PAS did not correlate with engagement or performance from the correlation analysis on Table 4. In contrasting the two groups, the motivated group's perceived autonomy support was higher than that of the demotivated groups. Student interviews yielded contrasting data on their experiences with the instructor and the research narratives. The motivated group reported a positive rapport with the instructor accentuating the comfort of turning to the instructor for advice and being able to choose the direction of their research narratives.

> I've been talking to Dr. Hertz as throughout the semester, I came to him and just started asking for advice because I didn't know what I wanted to do and he really helped me out a lot. … *I started off as this big project that I had to do and after I started talking with him, it (research narratives) became kind of cool. ... I plan on*

> *going back and talking to Dr. Hertz because I feel like he's got a lot of great insight (Austin)*
>
> *I felt like it was better because I could choose what I wanted and nothing was really forced. You had the choice…I'm glad we had that. (Austin)*

In contrast, the demotivated group reported feeling not appreciated or respected for their contribution to the class. One student expressed negative feedback about the student-centered course structure and complained about having to rely on others' accountability. Discussion between the instructor and students regarding negative feedback may motivate or demotivate students depending on how students perceive their psychological needs are supported (Reeve, Bolt, & Cai, 1999). Motivation is interpersonal in the sense that the quality of relationship between the student and the instructor affects motivation (Furrer & Skinner, 2003; Hanrahan, 1998).

Endorsement and value

Endorsement of the research narratives was promoted during Own it when students understand and internalize the value of research narratives. Twenty out of 24 students showed a positive attitude toward the educational value of research narratives in the presurvey. On the postsurvey, 7 of 21 students claimed either difficult or moderately difficult to understand why the research narrative was beneficial to them. From the result of the IMI postsurvey, value and interest were highly correlated (R=.88); students who considered the research narrative to be a valuable activity enjoyed working on it. Student interviews confirmed that student who expressed the value of the research narrative as a way to engage the public and who also advocated the value of public outreach reported they enjoyed working on the research narrative and expressed career interests in which narrative writing can be valued.

there is a huge gap between everyday people and the scientific community and those are the people that really matter when it comes down to it especially in conservation and just people being aware of things. (Austin)

I guess I really enjoyed getting the experience to kind of work on reaching out to other people ... I knew that could be critical for maybe a future job or anything (Austin)

I am really big into scientific education so it is a lot of my big forfeit. So any opportunity I can get to go pull somebody off the street. Just hey! this is Science. Check it out. This is awesome. Draw people into it. (Dave)

I really do believe that it is (valuable). It was just interesting. I've never written anything like that before. I have always been into creative writing. I've done a lot of short stories. So to be able to combine wild life and that has been a great experience. (Dave)

I think it was really good to learn how to write a paper like this because when you're trying to educate the public about a certain thing, you can't just educate somebody with throwing scientific facts at them like a typical research paper would (Sophie)

In contrast, students who considered the research narrative negatively did not enjoy the assignment and expressed apathy toward the relevance of narrative writing or public engagement in their future careers.

Things that are more important for me to do are to be able to write actual research papers, and actually do science. Because the science I want to do, the process of science is not similar to those of science I wrote about (in the research narrative). (MaryKate)

Personal goals

Students cross-selected personal goals they wanted to achieve through the research narrative in the presurvey. "Making connections with people in the field" and "learning to communicate science with the general public" were most selected (75% for both) and "becoming more interested in the field" (68%), "understanding a line of research conducted in the field" (54%), "helping other people understand better about the field"(50%), "understanding the human side of conducting a scientific research" (50%), "identifying a potential graduate mentor for me"

(50%) were selected consecutively. The main instructional objective of the research narrative, "understanding the general process of science" was selected the least (42%).

In addition, four anonymous students stated individual goals:

> *"Kella Girado (pseudonym) corresponded with me in middle or high school on his research about the natural history of cotton mouths and I am interested to meet him."*
>
> *"Much deeper understanding of herpetology in general"*
>
> *"Because I want to go into disease research, I am interested in talking to people involved in disease research. I like herps, but i am not a herpetologist and I really don't intend to be."*
>
> *"I would like to better my communication and writing skills and learn to bridge the gap between the scientific community and the general public. Future research project, publication."*

In the postsurvey, students reported the degree to which they felt they had achieved each goal (rank ordered in Table 4.5).

Table 4.5. *Students' Perceived Achieved Goals (N=22)*	Mean*	S.D.
Making connections with people in the field of herpetology	2.41	0.59
Learning to communicate science through writing for the general public	2.32	0.78
Understanding a line of research that was conducted in the field of herpetology	2.23	0.75
Helping others better understand the value of herpetology	2.23	0.75
Understanding the human endeavor of conducting scientific research	2.05	0.72
Becoming more interested in scientific research	2.00	0.82
Understanding the general process of science	1.95	0.79
Identifying a potential graduate or career mentor	1.55	0.74
*Options scaled at fully achieved (3); somewhat achieved (2); not achieved (1)		

The order of achieved goals was compared with the intended goals established in the presurvey. Making connections was both the most sought-after goal in the presurvey and most achieved goal in the postsurvey. In addition, student interviews reflected that the motivated group reported networking as a personal gain from the project.

> *I really, really liked having a reason to get closer to my researcher and for people who didn't know the person…it probably opened up a huge opportunity for them. … it could be a potential partner (Sophie)*

> *it kind of helped me see that's it's not so intimidating to reach out to people that you don't know because there is always someone willing to help somewhere that could really be useful for you in the future (Austin)*

However, students may not have fully understood the assignment until Allie stated, "the whole time I was really confused about what on earth we were supposed to do until I finally actually had it written" (personal communication, April, 2013). Lack of understanding of the assignment presents obstacles in the establishment of personal goals. This suggests the need for students to clearly understand the requirements, the rationale, and possible values for the research narrative. Furthermore, understanding of the assignment goals does not influence endorsement. One demotivated student reiterated the instructor's goals but not its value for learning the process of science in part by her disagreement of the design of the assignment and in part by its personal irrelevance.

> *The goal of this activity was to get us to go talk to a scientist, learn more about the process of science, write a narrative so write a science in an engaging way to communicate well with the public and teach us how to communicate science to people other than scientists because some of the scientists are not particularly well versed in. (MaryKate)*

> *I feel like at best these narratives do tend toward being disingenuous just because they talk about all cool and exciting parts about research. At best we are telling people science is cool, awesome, super fun great thing. (MaryKate)*

> *Neither the science I will be doing, nor the writing I will be doing. (MaryKate)*

Therefore, endorsement appeared to reflect congruence with personal relevance and value rather than understanding the assignment objectives.

Choice and flexibility

The more the students perceived choice, the higher their engagement. Students chose organisms and ecology issues about which they were passionate; the scientist conducting research per their interests gave advice not only on the topic but also on entering the field. Having choice and flexibility to customize the assignment to address individual needs and interests appeared to increase perceived relevance.

> *I really liked being able to write about loggerheads and I mean, writing about anything you're passionate about is going to be exciting … Everybody probably wrote about something they generally love and are interested in and that's probably the best part of it. (Sophie*)

> *I felt like it was better because I could choose what I wanted to go to and so nothing was really forced. It was more about being able to just…basically talk to somebody that you would care to share the information to and so it wasn't forced. You didn't have to exactly write to…children. You had the choice…I'm glad we had that. (Austin)*

Scaffolding

Students evaluated the usefulness of the scaffolding activities provided during Own it, Learn it, and Share it in the postsurvey. Table 4.6 shows the comparisons between the usefulness of scaffolding activities from the needs assessment and from the first iteration.

Instructor feedback on the first draft and the opportunity for revision were ranked as most useful followed by peer review and self-critique after the intervention. The new scaffolding activities added to the first iteration, including Research 101 workshop, researcher profile, cover letter, keyword icebreaker, story writing guidelines, and one-on-one writing tutoring, were ranked low in its usefulness.

The keyword icebreaker was intended to reflect and connect interests to topics related to the research narrative. While many students did not identify this as related to the research narrative, student responses confirmed that research narratives were connected to individual interests.

> *I didn't realize it was being related to the narratives at the time. … I thought it was a getting to know you thing then. (MaryKate)*
>
> *… a lot of things I wrote down in the paper ended up in my narrative because my narrative fairly well reflected my interests. (MaryKate)*

Table 4.6. *Comparisons of Useful Guidance Before and After Intervention*

Needs assessment Spring 2012	1st iteration Spring 2013
Feedback on the First Draft	Instructor's written feedback on the first draft
Opportunity to Revise	Opportunity to revise
Rubrics	Peer review
Instructions provided in the syllabus	Self-critique
Peer Review	Rubric
Example	Instructions provided in the syllabus
Self-Critique	Research 101 workshop
Individual Discussions with the Instructor	Researcher Profile
	Professional examples
	Cover letter
	Keywords Icebreaker
	Story writing guidelines
	One-on-one writing tutoring

Postsurvey results indicated that one student reported difficulty and nine reported moderate difficulty in identifying a scientist or a topic that matched their interest. Explicit reflection on one's interests appeared to help students to connect their interest to the topic of their choice. Overall, 15 of 16 attendees strongly agreed or agreed that the Research 101 workshop was helpful. Students listed the following as helpful: "The narrative project expectations were outlined more clearly;" "He mentioned potential questions that we could ask our person. This helped me better know what is expected of this assignment;" "Learning to use Google Scholar and Web of Science;" "Who to interview;" "Choosing a topic;" "Talking about how to reach out to the people we are interested in;" "What to include in email to researcher when first contacting them;" "Figuring out interview techniques." Students wished for conducting the workshop in the computer lab where they could "actually start searching for a person/ project which the suggestions were being given" and review "past examples" and "other sample narratives and evaluate what worked and what did not."

Eight students reported using the story writing guidelines and finding it helpful. In addition, a tutor was available to meet with individual student on a one-on-one basis to help with story writing. One student participated and found it very helpful. This lack of use of writing scaffolding may be why the students continued to struggle with writing, which includes blending science into a story, writing a creative story, deciding which content to include into story, and conveying scientific information to lay audiences.

Peer review was ranked as the third most helpful scaffolding, and nineteen students found peer review either somewhat or very helpful. Instructor feedback, ranked as the most helpful scaffolding, and was given to students following the peer review in the form of written comments on the first draft accompanied by the graded rubric. Students subsequently completed a self-critique form to self-evaluate their writing and make a plan for improvement in their own narrative. Self-critique was the fourth helpful scaffolding and two students did not find it helpful.

> *it definitely helped to do that in lab. Heard some things from the classmates that I probably wouldn't have thought of. … a lot of his comments did mesh with what the students said so that was encouraging to know they were saying the right stuff, too. (Sophie)*

> *"Well, I got lost at this point" or whatever. So, it gave a broader spectrum or view of what your paper really turns out to be and then, of course, what Dr. Hertz gave back was more focused. So, it really helped me to prepare for what Dr. Hertz would say. (Austin)*

> *We were all thinking in our minds when we were looking at somebody else's paper was, "Well, I did this better than they did and so I'll just write that down, that they didn't do this well because I feel like I did mine correctly" kind of thing. (Austin)*

So, doing (self-critique) helped me to recall it later from when I did revise and rewrite. ... I don't think that was like a game changer but I do feel like it's useful because it helped me but it wasn't as good as having something concrete. (Austin)

Then, students were given an option to revise and resubmit their drafts. Final submission required a cover letter in which students reflected on and summarized how they had addressed their plan for revision noted in their self-critique. Twenty students found the opportunity to revise as second most helpful, while 12 students indicated the cover letter was not helpful.

if there wasn't a second submission, I would not have done very well and that was critical. (Sophie)

I definitely put more work into the second submission rather than the first. ... I didn't really introduce a lot of scientific things before that point. One paragraph was just like a brick wall for our reader. So, I expanded it and broke it up into a few different pieces and also I explained evolution and climate change and temperature dependence on sex determination ... so that everything was there that they would need to understand what I was trying to say (Austin)

I felt like that (cover letter) was kind of pointless, too, because I just feel like it was an extended version of the self critique and I feel like he didn't give any sort of like…"This is how you should do this"(Sophie)

With respect to difficulty, narrative writing was again the most difficult task as students had to blend science into a creative story.

I think the biggest issue overall was organization. And that goes back to me having a hard time adding narrative and scientific in the same thing. You have a paragraph of a narrative and then the next paragraph is just strictly scientific information and I guess I was just bad at organizing it …I don't know, I tried to fix it as good as I could but I feel like he'll probably grade it and still be like…"it's not fully organized". (Sophie)

Compared to the previous year, less percentage of students experienced difficulty with searching for information, understanding the research process and scientific journals, and contacting and interviewing the scientist. Difficulty in understanding the value of the assignment was decreased. Table 4.7 displays the comparisons of difficulties reported from the needs assessment and after scaffolding activities were used.

Table 4.7. *Comparisons of Difficulties Before and After Intervention*

Needs assessment Spring 2012	1st iteration Spring 2013
Writing To Tell A Good Story	Blending science into a story
Critiquing My Own Work	Writing a creative story
Understanding Why I Have To Do This	Deciding which content to include in my narrative
Critiquing Someone Else's Work	Conveying scientific knowledge to a layperson
Contacting and Interacting with The Researcher	Interviewing a researcher
Conveying Scientific Information to a Layperson	Understanding the scientific journal
Identifying Content to Include in My Narratives	Contacting a researcher to interview
Motivating Myself to Do It	Identifying a researcher or a topic that matched my interest
Planning Out What to Do Next	Understanding why this assignment was beneficial to me
Understanding Content (10->11)	Searching for information about the topic or the researcher
Having Someone Critique My Own Work	Understanding the research I described in my narrative
	Searching for the scholarly article of my researcher

Learning the process of science

During the needs assessment, students focused more on story writing than on learning the process of science. Therefore, the current implementation focused on helping students enhance their understanding of the process of science, which was the main objective of the research narrative. In addition to OLSi scaffolding, several activities were implemented to shift the focus from creative writing to learning the process of science. First, the instructor increased the weight of science on the grading rubric from 35% to 50%. Second, each time the research narrative was being discussed, the instructor reiterated to the students that the narratives should focus on telling the story of conducting research in the real world. Third, the instructor's written feedback on first drafts encouraged elaboration on the science process.

At both the beginning and the end of the semester, all students reported their familiarity with the general process of scientific research as ranging from somewhat to very familiar. Students' self-reported familiarity with the process of science was slightly increased throughout the course. Two weeks into the course, 15 students reported the mean of 5.43 and Standard

Deviation of 1.12 for their familiarity with the general process of conducting scientific research while 22 students reported the mean of 5.55 and S.D. of 0.96 on the last day of class. Additionally, 64% of students reported their understanding of science had increased, while 36% reported it remained about the same. Student interviews showed their conscious efforts to describe the process of science in their narratives.

> *I was kinda thinking you know this needs to be more about the science. People are important and play a role in it but I feel like that needs to be a little of a back seat to that. They are important characters to portray but not necessarily the focal point of the story. … all I thought I needed interview for was to get that little bit more humanizing side of the story whereas I really wanted to focus on sciences looking at the papers (Dave)*

> *I really wanted to introduce python and introduce the problem and then talk about the study. Of course before that, I had to introduce who is conducting it to give people something more relatable to and latch onto when they read it. I kinda wanted to focus on here is the study, this is what it says, this is the problem, and this is why it is important convey it to your audience. (Dave)*

> *I got better perspectives on who these researchers were and I explained (in my narratives) why they are relevant, how valuable they are in the field. (Dave)*

The three objectives of the research narrative: (a) learning the process of science, (b) broadening perspectives in the field, and (c) networking were all fully and partially achieved by the students. While the most indicated that research narrative was a networking opportunity, students' narratives represented their understanding of the topic and the process of conducting research.

Audience

Six students chose not to publish their narratives, eight students chose to publish to peers on the course website, and the remaining eight students chose to publish to the real world audience in the public blogs. Responses to the open-ended question in the post survey included the following reasons for publishing: "*To force myself to try harder;" "I enjoy writing and* *wildlife and I would like to share that passion with other people,” and* “*I think it would be cool to have my writing, my thoughts, my feelings out on like this public website that anybody can read.*” Reasons for not publishing included: “*I am not confident in my writing*” “*I did not want to be restricted in the content or word count”* and *“It seemed like added pressure*.”

Students who intended to publish their narratives either to peer or real world audiences expressed hope that their stories would engage the public to change their beliefs and behaviors.

> *there is a huge gap between everyday people and the scientific community and those are the people that really matter when it comes down to it especially in conservation and just people being aware of things. ... , if you can get people to read it, you know, that’s one of the best ways to kind of reach everyone else that’s not in the scientific community (Austin)*

In addition, students reported the importance of knowing that their stories will be read by others.

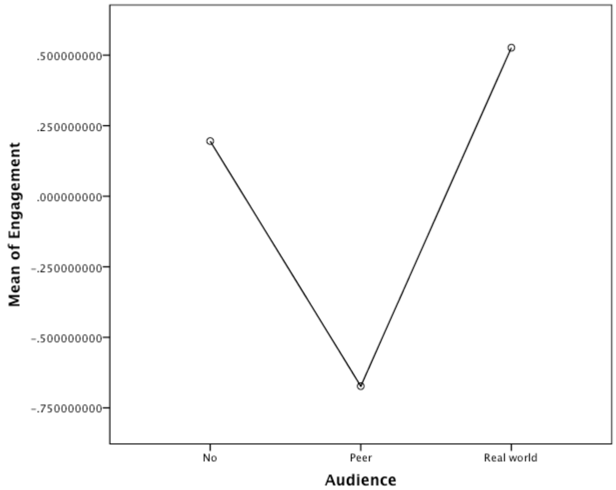
> *It made me work harder because I knew that other people were going to be reading it, it wasn’t just going to be me and Dr. Hertz and potentially (the scientist I interviewed), it was going to be tons of other people. ... I took the whole paper in general more seriously. ... because otherwise I probably would have not put forth as much effort as I did. (Sophie)*

Similarly, Gretchen published her narrative on a high-traffic blog, Living Alongside Wildlife focusing on how endocrine disruptors, chemical contaminants, may affect human reproductive systems soon after the course ended on May 7, 2013. As of April 8, 2014, her blog post had received 1260 view counts, 49 Facebook Likes, and original comments consisting of praises, readers’ perspectives on the issue, recommendations for further resources and scientists of similar interests, and questions. One reader asked for suggestions for taking action. Gretchen offered links to organizations’ mission statement pages and encouraged contacting organizations that align with interests and concerns. Another reader asked: “what do you think about the paradigm that the general public is exposed to chemicals and accepts them until scientists prove they are harmful?”

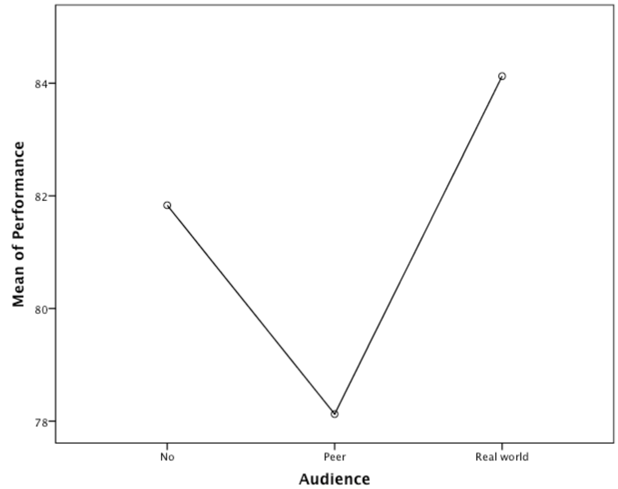
A one-way between subjects ANOVA compared the effect of audience on engagement, performance, and improvement between audience groups: no audience, peer audience, and real world. There was no statistically significant effect of audience on performance at the $p<.05$ level across the three groups [$F(2,19)=1.031$, $p = 376$] or improvement [$F(2,19)=1.406$, $p=.269$]. However, there was a significant audience effect for engagement [$F(2,19)=3.864$, $p=.039$]. Post hoc comparisons using the Tukey HSD, LSD, and Bonferroni test indicated that the real world audience condition ($M=.52$, $SD=.86$) was significantly different than the peer audience condition ($M=-.67$, $SD=.82$), but difference between no audience condition and real world audience conditions.

Figure 4.4 displays the means plot for engagement, performance, and change by audience choice. The peer audience group's engagement and performance was the lowest; in contrast, peer audience group improvement was the highest. Four of eight in the peer audience group revised the narrative and improved their scores, which derived a mean of 6.50, higher than no audience (2.13) and real world audience groups (2.83).

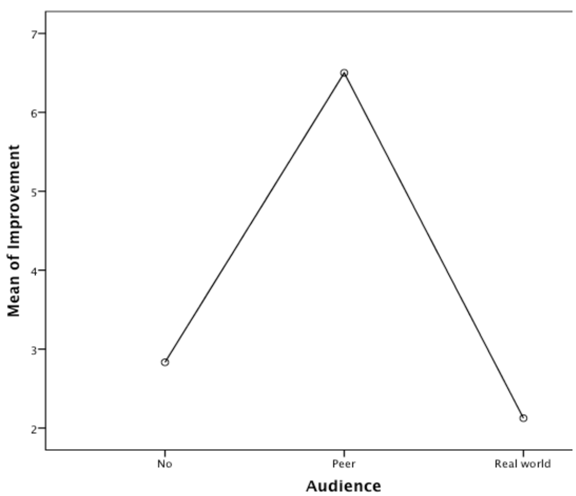
Since p-values may prove ineffective in assessing the strength of relationships in this sample (Cohen, 1992), effect sizes demonstrate a strong relationship between peer audiences and real world audiences for engagement (Cohen's $d=1.41$), performance (Cohen's $d=.66$) and improvement (Cohen's $d=.75$). In effect, these results suggest that addressing real world audiences has an effect on all engagement, performance and improvement. Our findings indicate that when students wrote narratives for real world audiences, both engagement and performance increased. Student identity with identified audiences and the scientists improved the quality of and the engagement.



Engagement comparisons by audience choice



Performance comparisons by audience choice



Improvement comparisons by audience choice

Figure 4.4. Mean plots for engagement, performance, and improvement by audience

General Discussion

This study examined the extent to which autonomy, scaffolding, and audience influence engagement and learning the process of science in student-centered college science learning environments. The OLSi framework provided support for scaffolding autonomy support, student-centered inquiry, and writing for target audiences. Student engagement was supported in this study and previous research: The more engaged with the autonomous SCLE project, the better the student performance.

Autonomy assumes more than only shifting control in student-centered learning. Endorsing the value of assignments, achieving personal goals, feeling competent, and having positive relationships influence engagement and performance according to Self-Determination Theory (Ryan & Deci, 2000). Own it emphasizes student autonomy when the instructor provides choice and flexibility, facilitates an opportunity to endorse the value of the activity, and encourages students to set and evaluate personal goals.

Providing student choice and flexibility has proven essential to make assignments meaningful as they relate to individual academic and career interests (Reeve & Jang, 2006). Providing assignment rationale and encouraging students to consider personal benefits from the assignment appeared to strengthen endorsement of the instructional goal. Whether students endorse the value of an assignment or not, students are still responsible for setting personal goals and making assignments relevant and meaningful given the flexibility to do so. However, many students did not initially recognize the depth and extent of projects until they first attempted to complete them. SCLEs need to promote constant reflection and establishment of goals and plans as students' understanding emerges (Hannafin, Land, & Oliver, 2013).

Autonomy support is influenced by relationships with the instructor and how their needs and interests are respected and addressed (Ryan, La Guardia, Solky-Butzel, Chirkov, & Kim, 2005). The motivated students reported positive rapport and expressed appreciation for the instructor's help and expertise; in contrast, demotivated students expressed indignation with the instructor. Likewise, the extent to which students related to the scientist they interviewed influenced engagement. Students who connected with the scientist interviewed reported a fruitful conversation, and subsequently revised their assignments and improved their performance. These motivated students planned on sharing their final drafts with the scientists, and published their narratives to others.

Constructivist researchers cite the importance of scaffolding SCLEs (Wilson, 1990). Providing scaffolding aligned with Self-Determination Theory increases perceived competence, which in turn, influences engagement, performance, and creativity (Deci & Ryan, 2000). Scaffolding guides students to think, construct knowledge, and generate artifacts that represent individually constructed knowledge (Hannafin, Hill, Land, & Lee, 2014). The combination of scaffolds was essential due to the multitude of skills required in the complex process of student-centered learning tasks. Expert modeling (Pedersen & Liu, 2002), direct instruction (Schwartz & Bransford, 1998), question prompts (Ge & Land, 2003), peer review (Trautmann, 2009), and reflection (Choi et. al., 2005) assisted students' autonomous process by establishing learning goals, investigating the process of science in the real world, and writing the research narratives.

Compared to student understanding of the process of science from the initial needs assessment, in the current study the narratives emphasized describing the process of science; students' familiarity with the general process of conducting research improved. Explicit scaffolding activities for endorsing and setting goals influenced perceived value of the activity. While new guidelines for narrative writing were offered, few students used them; unfortunately, their influence was not demonstrated.

Overall, curriculum-wide attention to writing skill improvement is vital in postsecondary education. In the current setting, we focused on learning the process of science rather than learning to write rhetorically. While communicating science in everyday language is important for learning science (Gunel, Hand, & McDermott, 2009), science instructors typically dedicate only limited attention to improving writing skills. Instead, partnering with and capitalizing on external resources such as mandatory freshmen composition courses, writing tutors, and science librarians could be an alternative.

This study also supported existing research on increasing engagement and performance for generating artifacts for real world audiences (Cohen & Riel, 1989; Kearney & Schuck, 2006). Student artifacts represent value beyond course assignment and catalyze personal interest such as increasing the awareness of the sea turtle mortality by boat strike. Their artifact will be long lasting and continuously accessed, read, and commented on by real people. Their artifacts become the catalyst for making a difference in the world. These attributes of authentic artifacts elicit personal investment on the quality of student work and thereby increase engagement and performance.

Researchers recommend that students not only design and create but also discuss their work with the audiences (Evard, 1996; Kafai & Resnick, 1996; Kolodner et al., 2003). The public view and comments represent further opportunities for discussion and learning. Promoting dialogue between the author and the reader and involving the scientist in the discussions may offer added value in engagement and learning science. Addressing audience questions and comments synchronously or asynchronously appears to foster investigation. Students need to explain, justify, answer questions, and further elaborate their findings, interpretations and conclusions. Learning occurs through iterative cycles of reflection and revision as students refine understanding of concepts and associated skills (Kolodner et al., 2003).

Social media invite discussion for posing questions, answering and sharing. The role of blogging and microblogging (e.g., Twitter) as an educational tool to enhance active participation in a postsecondary setting has recently been highlighted (Cakir, 2013; Junco, Heiberger, &

Loken, 2011). Students attempt to connect with experts to learn and share learning artifacts with the real world audiences. Follow-up studies on dialogues with real world audiences should further guide uses of social media in informal learning.

Yet, some highly engaged students chose not to address real world audiences. Students reported reluctance to making their work available and accessible and noted unknown risks. Students should investigate the details of the publication venues such as author guidelines, readership, popularity, and implications for publications. Also, education about Internet publishing guidelines should precede the publication.

The Current and Future Iterations

Based on the student data and informed by the OLSi framework, another design iteration in Figure 4.5 was implemented in Spring, 2014 (See Appendix S for updated assignment instructions and Appendix T for updated rubric).

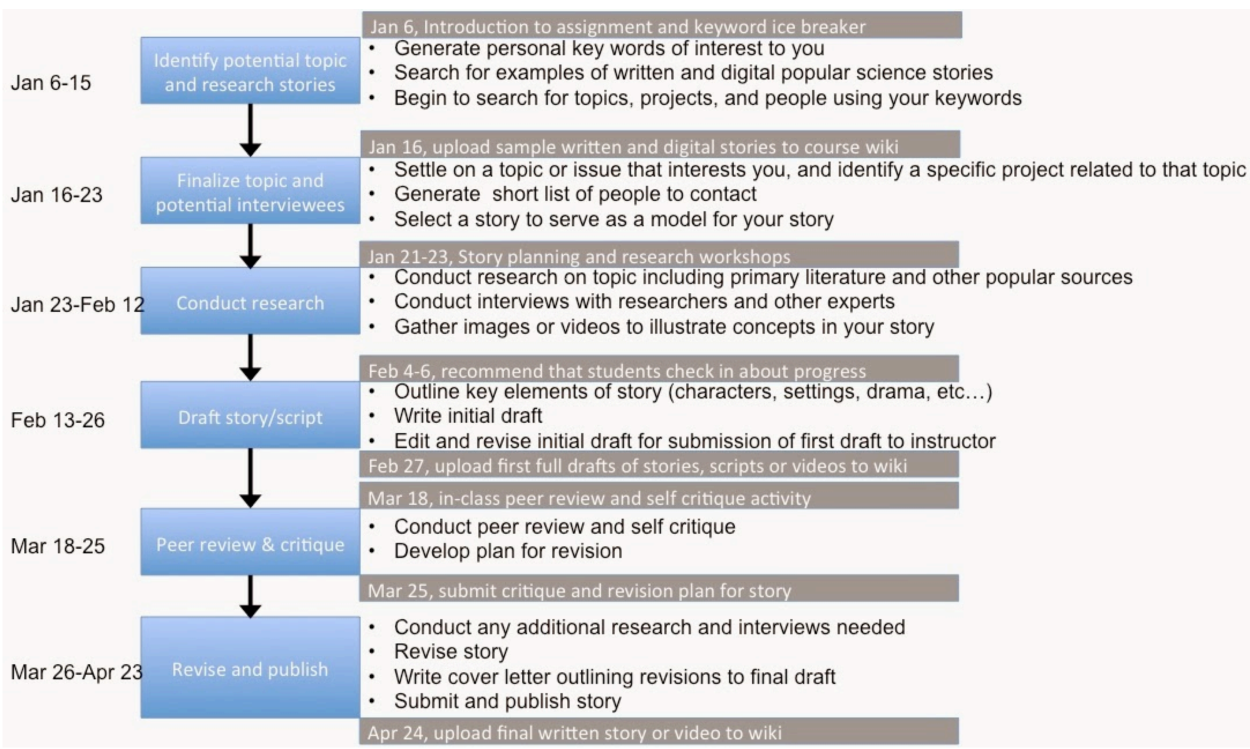


Figure 4.5. Research narrative milestones for spring 2014

Own it set the stage for understanding the assignment requirements and establishing personal connection. The autonomy building scaffolds were modified and extended:

- Popular science story: In lieu of using research narrative as the title of the project, popular science story was used to better represent the common usage of story to communicate science to the general audience.
- Choice of written or digital story: Students could choose to produce either a written story a digital story made up of videos, images, and text to reconcile with their lack of story writing competence and a preference of digital imagery communication.
- Keyword icebreaker (APPENDIX U): The keyword icebreaker was designed to show a clear association with the popular science story. To do so, the keyword icebreaker was facilitated after the introduction of the popular science article during the lab and guided students in the use of personal keywords to identify research topics and scientists. In addition, no topic keyword was assigned.
- Find your own example: In addition to providing professional examples, students found their own examples better suiting their individual topic and format. It is expected that in search of examples, students gain better understanding of the assignment and expose themselves to a variety of contexts that the popular science stories are used.

Learn it continuously focused on helping students conduct independent inquiry to learn about the process of conducting research and interviewing scientists. Before attending Research 101, students posted profiles of potential scientists and sample stories on the course website. Research 101 was conducted in the same voluntary fashion. Google Scholar demonstration included the use of the keywords students identified during the keyword icebreaker in order to locate relevant primary literature and scientists. Students positively responded to receiving advice on how to contact and interview scientists and further direction on writing a story.

Share it again focused on scaffolding writing, facilitating peer review, self-critique, revision, and the final cover letter. Story writing guidelines were posted on the course website from Day 1. Multiple attempts was made to advertise its availability to ensure student's access to the guidelines. The first draft was submitted earlier before spring break as the course load tended to get heavier close to mid semester. The attachment of cover letter to their final draft to outline revisions should be reinforced.

Above changes were implemented during mid-April, 2014. The data from the current iteration is yet to be collected and analyzed to further refine and inform future iterations. Recommendations for future iterations include online peer review to allow additional time for reading and commenting after in-class peer review (See Appendix W for updated peer review, self-critique, and cover letter instructions and Appendix V for peer review worksheet.) Additionally, students can identify their own publishing venues such as a local newspaper as their stories may have specific target audiences in specific regions. Follow-up on students' publication of stories and ongoing dialogues with audiences is encouraged. Students may sign the release form of their stories to be published for peers in the course website. This should simplify the instructor's follow up with individual student in order to make their work available as student examples.

Limitations and Looking Ahead

The principal goal of this study was to present evidence related to the implementation of a theoretically-grounded design framework to scaffold a student-centered learning environment. This design research study was an initial attempt to improve a student-centered, science learning environment in the real world college course setting. The classroom is a messy context of numerous, interconnected factors in which establishing warrants is particularly difficult (Shavelson, Phillips, Towne, & Feuer, 2003). In order to address the issues associated with real world classroom context and limited participants, we triangulated data to capture and determine the influences of the OLSi framework.

The course level SCLE presents a unique set of challenges (compared with curriculum-level and institution scales). This study attempted to optimize course-level, student-centered learning strategies in a specific college science context. The strategies have yet to be further scrutinized for potential broader implications. Multiple iterations of implementation, evaluation and refinement in diverse contexts are needed to validate design principles applicable beyond the course level SCLE (Design Research Collective, 2003).

Another potential limitation was the use of an absolute difference score to measure changes from first to final draft revision as the improvement variable. The absolute score change might not provide a proportional indicator of change. Students who received high initial scores may have had limited potential for improvement while those who received low draft scores may have yielded proportionally greater absolute improvement score increases. In addition, more than 50% of students chose not to revise which resulted in no change from initial to final drafts, which may suggest a floor effect. Further analysis of the improvement measure is needed to determine whether the use of an absolute change score influenced our analysis and interpretation (Lewis-Beck, Bryman, & Liao, 2004).

Furthermore, correlations between improvement and engagement represent linear relationships. The engagement variable was extracted from a principal component analysis of the six IMi variables and represents unbounded variable while the improvement score may have been artificially bounded due to restricted potential for change. Thus, the linear analysis involving unbounded and bounded variables to examine the relationship between engagement and improvement may potentially limit the overall analyses and interpretations.

Several questions remain. First, relationships matter. Relationship with the instructor influenced both engagement with the assignment and the overall course experience. Previous autonomy research emphasized the importance of connectedness with the teacher in engagement, concentration, better time management, self-regulation, and improved performance (Reeve & Jang, 2006; Reeve, Jang, Carrell, Jeon, & Barch, 2004; Reeve, Bolt, & Cai, 1999). Applied to online learning environments, Yang et al. (2006) reported when college students perceive connections to instructors, perceive self-efficacy and task value also improved. Flowerday and Schraw (2000)'s phenomenological study focused on how teachers provide choice and in turn what effects choice have on students. Personalities, beliefs, and interactions influence individual's lived experiences in the classroom. A phenomenology study will shed light on the both students' and teachers' intentionality and experience toward the power dynamic of student-teacher relationship when they are imposed on non-traditional roles in an autonomy supportive learning environment.

Next, students' increased or decreased motivation, engagement, and performance during the course were likely influenced by many factors. We need to further examine to what extent performance and participation were mediated by the scaffolding and support activities compared with initial motivation at the first day of class. Additionally, previous research suggests that the process of designing and creating artifacts promotes learning. We need to further investigate the influence of dialogues between students and real world audiences including experts, peers and the general public particularly in pervasive social media, which enables instant access and dialogues across borders and times.

We believe design research can guide designers and instructors to adapt scaffolding frameworks through which students assume increased responsibility and autonomy and subsequently enhance engagement and performance in a student-centered, constructionist learning environment.

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CHAPTER 5

AUTONOMY SUPPORT FOR ONLINE STUDENTS[4]

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Abstract

Despite the rapid growth of online learning in higher education, the dropout rates for online courses have reached 50 percent. Lack of student engagement rank as a critical reason for frequent online course dropout. This article discusses autonomy support as a strategy to enhance online students' intrinsic motivation and engagement. Drawing from current theories and research, three guidelines are offered to provide choices, rationale behind why assignments are designed in particular ways, and flexibility in completing more personally meaningful assignments. Each guideline is accompanied with examples from existing higher education courses. This article is intended for educators and designers of online learning to employ autonomy support strategies to engage students in active participation and successful completion of the course.

Keywords: autonomy support, engagement, higher education, online learning, self-determination theory

Introduction

Online learning is increasingly offered in the ever changing landscape of higher education. Rates of students enrolled in at least one online course have consistently grown from 10 % in 2003, to 25 % in 2008, to 30 % in 2011, to 33.5% in 2013 (Allen & Seaman, 2011; 2014). Despite this remarkable growth, online courses face an ongoing chronic dilemma—a higher dropout rate than traditional face-to-face courses (Tinto, 2006; Patterson & McFadden, 2009). Only 50% of enrolled students complete their online courses (Angelino et al., 2007) whereas the completion rate of Bachelor's degree seeking students at 4-year institutions reached 59% in 2011 (U.S. Department of Education, 2013).

Among many factors attributable to online course dropout, the lack of self-regulatory skills is one area of focus (Lee, Choi, & Kim, 2013). Successful completion of online learning largely depends on maintaining active engagement in the course activities (Bennett & Monds, 2008) and requires strong self-regulatory skills and increased autonomy (Lee & Choi, 2011; Muilenburg & Berge, 2005; Song et al., 2004). This paper examines the construct of engagement and motivation to inform the design and facilitation of autonomy supportive online learning environments.

Engagement and Motivation

Engagement, or students' participation and investment in learning activities, is important in online learning because it can increase learning and reduce educational risks such as dropout (Finn & Zimmer, 2012). Engagement enables meaningful interactions between the student and the internal and external factors of learning, such as student participation, attention, and desire (internal factors) and instructors, peer interactions, course design, and classroom climate (external factors) (Finn & Rock, 1997). Engagement manifests itself in behavioral, cognitive, and affective spheres (Fredericks, et al., 2004), especially in online environments where student participation and external factors vary from the traditional classroom model (Hoskins, 2005). For example, behaviorally engaged students log in, attend to course prompts, ask questions, read course materials, participate in discussions, complete assignments, and follow expectations. Cognitive engagement involves intellectual endeavors needed to search, evaluate, and select relevant and credible sources of information on the Internet and apply emerging knowledge appropriately to a variety of contexts. Affectively engaged students feel satisfied from their achievement, enjoy interesting activities, and maintain a sense of self-worth in peer interactions. Each form of engagement is imperative for students to fully immerse in learning and successfully complete the course.

Equally important to engagement in online courses is motivation, as engagement has been conceptualized as, “the manifestation of students’ motivation” (Schunk & Mullen, 2012, p. 220). Students’ motivation is translated into engagement where students not only have the desire to participate, but also actively participate in learning tasks. Self-determination theory suggests that motivation can range from controlled regulation (completing an activity to gain a certificate or avoid a demotion) to autonomous motivation (the award arises from completing the activity). (Ryan & Deci, 2000). Deci and Ryan (2000) suggest that the highest form of motivation is closely linked to satisfaction arising from a sense of autonomy, which in turn influences engagement, performance, and persistence. Online students come to class with complex blends of motivational levels (Artino, 2008; Harnett, St. George, & Drone, 2011), which is why supporting student autonomy is important to consider with regard to facilitating successful course completion.

Autonomy and Autonomy Support

Autonomy is considered a fundamental psychological need to function independently with will, choice, and self-determination (Deci & Ryan, 2000). When students are autonomous, the locus of control resides within students believing they can control events affecting their performance, and how the outcomes of their actions are based in their own decisions and abilities (Rotter, 1954). Autonomy is an important construct of motivation in self-regulated, online learning environments (Chen & Jang, 2010). When afforded autonomy, students are engaged affectively; students feel the sense of ownership and responsibility for the work they perform. Further, autonomy influences students' behavioral and cognitive engagement as they direct their actions, as well as determine and evaluate their goals and decisions. For example, Mullen and Tallent-Runnels (2006) found that students' perceived academic and affective support was positively related to task value, satisfaction, and learning in online courses. In addition, Joo, Lim, and Kim (2013) reported that locus of control, self-efficacy, and task value significantly influenced satisfaction, which in turn influenced persistence in college online learning.

Given the importance of autonomy for students, particularly in online environments, what is the best way for instructors to facƒilitate these experiences? Research has shown that students perceive autonomy in their learning when the instructor supports their interests, preferences, values, and psychological needs (Deci & Ryan, 2000). Further, students exhibit emotional connections with instructors who support their autonomy (Ryan et al., 2005). Thus, the instructor's support of students' autonomy is favorably related to their engagement, concentration, time management, and self-regulation (Reeve et al., 2004). Further research shows autonomy support should be accompanied by the provision and parameters of structure. Structure can take a form of rubric, examples, graphic organizers, incremental milestones (e.g., dues for outline, first draft, and final draft), peer and instructor feedback. When combined with structured guidance, autonomy support is effective in fostering students' feeling of competence, time management, and self-regulation (Jang, Reeve, & Deci, 2010; Sierens et al., 2009; Van Loon et al., 2012), ultimately leading to greater learning outcomes (Baeten, Dochy, & Struyven, 2013; Su & Reeve, 2011).

In online learning environments, instructors are challenged to provide guidance, directions, and expectations through autonomy-supportive means to promote students' engagement. Because engagement is malleable (Fredericks et. al., 2004), there are strategies instructors can employ to promote an autonomous learning environment conducive to student engagement. This article discusses such strategies to support student autonomy in order to enhance behavioral, cognitive, and affective engagement in online courses. Grounded in current research, we offer three guidelines to support student autonomy in relation to addressing students' internal locus of control through providing choice, the rationale of an activity's value, and an invitation for each student to make a personal connection to the course activities. Each guideline is accompanied by a brief, practical example. At the end, we provide two overarching examples that encompass elements of all three guidelines. This article sheds light on potential ways that instructors and designers of online learning can access and promote students' autonomous motivation for their active engagement in and successful completion of online courses.

Guideline 1: Provide Choices.

Fostering autonomy involves providing choice as part of student engagement with course activities (Reeve & Jang, 2006). Choosing among several options is designed to increase students' perceptions of internal control over their actions (Reeve, Nix, & Hamm, 2003). When afforded choices, students tend to spend more time and effort on the activity (Flowerday & Schraw, 2000). Patall, Cooper, and Wynn (2010) reported when instructors provided choice, students exhibited more autonomous motivation, perceived higher competence, and resulted in higher completion rates and better performance compared to students who did not have a choice. Naturally, balance is critical, as too much freedom and choice could be overwhelming and wasteful, resulting in students resenting the efforts necessary for effective decision-making (Schwartz, 2000).

In online learning, instructors may provide several options for assignments and activities that best demonstrate the student's attainment of learning outcomes. Further, instructors should purposefully limit the number of choices and explain a predetermined parameter of each option so that students can understand the opportunities and challenges associated with each. The nature of student choice can also provide instructors with valuable feedback about which assignments are working most effectively. In Example A below, students were given a choice to explore different approaches to instructional strategies – they had the opportunity to select an instructional strategy of their choosing, group size (individual or pairs), and presentation format. The instructor also set the parameter of choosing from a finite list and creating a single page summary to provide structure.

Example A. Choices provided from a course on experiential education

Comparative Exploration Project (completed individually or in pairs):
Either individually or in pairs, you are asked to select an approach to education. I will provide a list of potential educational approaches. Once a selection is made, you will compare this approach to that of experiential education. Each group will be responsible for creating a single page document summarizing your selected approach and comparing this to experiential education. Additionally, you will present this approach to the entire class during our weekly synchronous meeting (creativity and innovation is applauded).
(Full syllabus available at the University of Georgia Syllabus System: https://syllabus.uga.edu/Browse.aspx Search Pate, Joseph, RLST 3130)

Guideline 2: Provide rationale**.**

Alternatively, students could have only one option and still feel autonomous. Autonomy applies to acts evoked by voluntary consent to external inputs such as required assignments and mandatory course policies (Ricoeur, 1966). Students can perceive autonomy even when acting in accordance with an external demand insofar as they fully concur with, or endorse, doing so (Deci & Ryan, 2000). Jang (2008) found that students who received the rationale showed more autonomous motivation, used interest-enhancing strategies, and increased behavioral engagement, and enhanced conceptual learning while completing a relatively uninteresting activity. Instructors should help students endorse an assignment by providing an explanation and rationale (Reeve et al., 2004). Example B communicates the instructor's perspective on why writing a teaching philosophy statement is valuable in an introductory education course.

Example B. Rationale for a teaching philosophy statement

One of the keys to this course is discussing current issues in education and reflecting on your thoughts about these ideas. By writing your philosophy of education, it gives you a chance to think about where you stand in relation to teaching and what your goals are as a future educator. A teaching philosophy statement describes how you view teaching from a professional and personal point of view. Further, a teaching philosophy statement is often required in your application to your major and often by school systems when you apply for a job. By writing one in this course, you will have a document that has been reviewed by your peers in writing circles and has instructor feedback, ultimately helping you to leave the course with a document and dialogue you can take with you as you begin your teaching career.

(Full syllabus available at the University of Georgia Syllabus System: https://syllabus.uga.edu/Browse.aspx Search Cozart, Deanna, EDUC 2110)

Guideline 3: Provide opportunities for personalization.

Students feel autonomous when the teacher respects and accepts their individual interests (Reeve & Jang, 2006) and provides flexibility for students to customize course activities so that they are closely connected to the students' academic, personal, and professional interests. When students work on personally meaningful projects, they become invested in these assignments and initiatives and motivated by the relevancy to their lives. Research has shown when students feel a personal connection to content and assignments, they are more invested in the outcome and more likely to complete such assignments (Patall, Cooper, & Wynn, 2010). Arguably, whether experiences are truly educative "depends upon the quality of the experience, whether or not it is engaging to the student, and if the experience has continuity with the student's further experiences" (Estes, 2004, p. 146). Additionally, student personalization of assignments can give instructors insight into topics that could perhaps be outside of his or her expertise, but of interest to individual students, creating a larger learning community.

In Example C, both explicit and intrinsic course objectives were presented to students. The explicit objectives exemplified traditional course objectives focused on measurable outcomes students were to attain through the class. The second set of course objectives represented the desired intrinsic outcomes that could occur through personally relevant and meaningful connections between course content and one's place in the world. Here, the intent is through both sets of course objectives for students to make personal connections to the content and see how the course's content can have relevancy beyond the classroom. While this course has been offered face-to-face, the implications are pertinent to online courses.

Example C. Connecting personal values to course objectives

Course Objectives - *Explicit*
Demonstrate knowledge of the history, goals, and philosophy of interpretation
Define the principles of education in non-formal settings
Evaluate the role of persuasive communication and conservation ethics in interpretation
Identify agencies, practical implications, and professional opportunities in interpretation

Course Objectives - *Intrinsic*
- Explore what it means to connect to/with culture and the environment
- Assess your own learning style and what motivates you to learn
- Establish a connection between self to self, self to others, and self to the culture and environment through intentional experiences and reflection

– Explore the mediums of art, literature, lived-experiences, movies, songs, etc. in relation to connection to self, others, and life

Connection (25% of total course grade)
As important as content or curriculum may be, one must find a connection of that curriculum to their personal lives in order for it to 'mean' something. This course is intended to 'mean' something to you. It is beyond the ability or scope of the course or the instructor, however, to control or dictate this 'meaning.' You are expected to create and establish this connection to meaning in a way that best meets you where you are. This portion of your grade will entail a combination of the following assessments:

- Weekly Journal (10%): We will discuss as a class and individually what form and focus these should take. The main focus is a springboard for further thinking inspired by course content, or as a clearinghouse where different thoughts can be surveyed
- Culminating Project on Connection (15%): An essential outcome of this course is for you to walk away with a project that captures your understanding of what it means to connect, through the course content, readings, discussions, etc. For a culminating project, you may use an "Open Canvas" approach as you create, pitch, and capture Connection in a unique and personalized way.

(Full syllabus available at the University of Georgia Syllabus System: https://syllabus.uga.edu/Browse.aspx Search Pate, Joseph, RLST 4840)

Overarching Examples

We proposed three guidelines to support student autonomy in relation to addressing students' internal locus of control, the endorsement of activity value, and to making a personal connection to the course activities. In the following section, we present two examples of autonomy supportive assignments that represent all elements of the three guidelines introduced above. We highlight the specific language that shows each guideline and explain how it unfolds.

In Example D, online students are given eight possible journal topics and select four to complete over the course of the semester. This assignment has been effectively used in both fully online and blended course formats as a semester-long project. Because there is a variety in both the subject/content of the prompt and the action involved, students can select topics that are of greatest personal relevance to pursue deeper reflection. A rationale is provided for both the overall assignment and the individual topics. Additionally, students are provided with structure such as the prompts and number of responses. Through choice, rationale, structure, and invitation to personal relevancy, students gain a greater sense of autonomy in the course.

Example D. Journaling

One of the keys to this course is discussing topics of difference that may make you feel uncomfortable or challenge your previous thoughts and experiences. I believe one of the best ways to deal with this internal conflict is to write and reflect on your experiences. There are eight journal topics relating to our class readings, discussions, and activities. You may choose four of the eight to respond to. Please make your 400-word responses available for my viewing in your personal blog.
Sample abridged prompts:

1. **Rationale:** Social class is one of the most important concepts we will discuss this semester – it infiltrates who you are, your goals, reactions, and expectations, all of which you take into the classroom with you. It is important for you to consider your own background as you prepare to teach in a classroom full of students whose backgrounds may be significantly different.
   Assignment: Think about the community in which you grew up and the class of your family and other members of the community. How would you describe the class of your family? What was the class of the majority of students in your high school? How do you think class influenced your educational aspirations and those of your high school peers?
2. **Rationale:** We live in a society that operates largely from a gender binary perspective – there are only male and female and specific behaviors that accompany those. However, we know for many students, male and female may not be comfortable terms for them or may make them feel isolated. As you prepare to teach all types of students, it is important for you to consider how gender identity is formed and what inputs influence how we communicate our gender to others.
   Assignment: Gender identity is a continuum of traits and behaviors that range from very feminine to very masculine. What are your thoughts about your own and others' gender identity? How do you and your friends identify people who act like the opposite sex? Which sex suffers the most from behaving like the opposite sex? Why?
3. **Rationale:** One of the goals of culturally responsive teaching is to validate the cultures of students as you teach. All students should see themselves in the curriculum, even though this is not always the case. As you prepare to enter the classroom, it is important for you to be aware of bias in our curriculum and the role that it may have in how your students relate to learning.
   Assignment: How would you feel if you never saw yourself, your family, or your community in the curriculum except in a negative way? How could you incorporate the cultures of your students into the subject you plan to teach?
4. **Rationale:** It can be difficult for people without disabilities to fully understand the challenges people with disabilities face on a daily basis. Because you will be teaching students of all different ability levels, it is important for you to consider school experiences for students with different types of disabilities.
   Assignment: To help you understand this, go to the following website (http://www.pbs.org/wgbh/misunderstoodminds/attention.html) and complete the visual or auditory activity relating to attention problems. Then, respond to the following questions. Which activity did you complete? How would having this type of disability make school challenging? Why is it important for teachers to understand the perspectives of students with disabilities?

(Full syllabus available at the University of Georgia Syllabus System: https://syllabus.uga.edu/Browse.aspx Search Cozart, Deanna, EDUC 2120)

Example E presents an unusual narrative writing assignment in which students interview a scientist and write a story about a research process in a postsecondary, face-to-face, science course. The assignment is largely open-ended for students to interject their personal, academic, and career interests; therefore, making the assignment personally meaningful to students. The instructor supplied the objectives and rationale of the assignment as well as parameters such as guiding questions, incremental milestones, rubrics, examples, and a list of potential interviewees. Finally, the instructor offered choices with regard to attending an optional help session and the publication of the student product.

Example E. Research narratives

Assignment Description	**Applied guidelines**
Research Narratives (20%) This activity has three objectives. The primary objective is to use current research in herpetology to foster a better understanding of science and the research process. The second objective is to provide an autonomous [self- directed] activity that enables each student to relate this course to their personal interests in herpetology through the exploration of a specific line of research and the people involved in that research. Finally, for those students interested in careers in biology, the research narrative process is a means to identify prospective graduate or career mentors.	Instructor describes explicit objectives that guide students to establish appropriate personal goals
So, what is a narrative and why a narrative as opposed to a traditional research paper? There is mounting evidence that narratives are an excellent way to build an understanding of science as a process. Traditional science papers are organized in a manner to convey information concisely and clearly so that the methodologies and results can be critiqued and replicated. As such, the primary scientific literature is not necessarily effective at communicating research to a general audience, and it does not necessarily highlight the research process and human endeavor of scientific discovery. People are more accustomed to narratives [story telling] as a way of understanding how events build upon the sequence of prior events and the actors [protagonists] in those events. So, rather than write a traditional research paper, you will write a story about a research project and a person you identify.	The instructor explains the rationale why narrative writing is an effective way of learning the process of science.
Parameters: (1) the person you write about cannot be a course instructor, and is preferably from an institution other than our University, (2) you must be able to conduct 2 - 3 interviews with this person (by phone, Skype or in person), and (3) your instructors must approve the person you will profile. Note, you accept full responsibility for communicating with your interviewee, and non-responsive interviews will not be considered a valid excuse for late or incomplete work. We strongly recommend you select someone with whom you have made contact and have arranged availability to interview.	Note that instructor set boundaries and discusses expected challenges.
This is an autonomous activity that requires your attention throughout the semester; however, we will provide you structured guidance and support throughout the semester including clear milestones and structured activities.	Instructor's call for student autonomy and responsibility
Optional Help Session In support of your research narratives, we will offer an elective, 1-hour workshop demonstrating various strategies to go about understanding the research project you	**Choice:** Students can choose to attend an optional workshop if they desire to receive

highlight in your narrative. We will go over how to identify and access primary literature, how to conduct an interview, and how to identify and integrate different research elements.	extra support or extra credit.
Publication Options Since you are writing a narrative to the general public, you have an option to publish your final narratives. First, you may publish your narrative to the course website so you have a safety net of sharing your work with your peers. Further, you may publish your narrative to a public website.	Also, students have the choice of publishing their stories to peers or to the general public.
(Full syllabus available at the University of Georgia Syllabus System: https://syllabus.uga.edu/Browse.aspx Search Maerz, John, WILD4040, Spring 2012)	

Conclusion

In this article, the three guidelines of providing choice, rationale, and opportunity for personalization were forwarded to facilitate and support student autonomy. Each guideline was accompanied with assignment descriptions as examples from various course syllabi that utilized these approaches. Online instructors encounter similar problems with student motivation regardless of fields of study. Research suggests that it is paramount to create autonomy supportive learning environments to enhance engagement, performance, and persistence (Baeten, Dochy, & Struyven, 2013). By providing choices, explicitly stating the motivation and rationale for course assignments, and allowing students to make learning activities personally relevant and meaningful, student engagement within online courses can be increased. With these strategies in place, instructors can enhance students' malleable engagement by supporting students to develop more autonomous levels of motivation, which in turn can lead to greater success in online courses. Facilitating student autonomy has the potential to transcend the course and be applicable in future contexts and life situations. This article provides examples from a diverse cross section of courses and instructional strategies grounded in current scholarly literature, but further empirical research to support these approaches is needed.

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CHAPTER 6

CONCLUSION

The studies and manuscripts presented in this dissertation represent the products of an ongoing design-based research (DBR) initiative to generate evidence of the impact of student-centered learning in post-secondary settings. DBR involves a systemic method to optimize an innovation by iteratively implementing, evaluating, and refining theoretical interventions (Brown, 1992). Researchers identify a theoretically grounded approach to implement research collaboratively in authentic, and often messy, everyday settings (Design-Based Research Collective, 2003). DBR supports and advances systemic approaches to pursue socially responsible research (Reeves, Herrington, & Oliver, 2005). This dissertation aimed to address important and complex problems in a real world context to identify, validate, and refine design strategies that may be applied to broader contexts. This dissertation contributes to our knowledge related to learning, design, and technology by suggesting and evaluating a synthesized framework of engagement design for a student-centered learning environment.

In the current program of inquiry, self-determination theory and related learning theories inform ongoing research and inform practice continuously. By optimizing the collaboration between the researcher and course instructor, this program of inquiry identified, evaluated, and refined design solutions to facilitate learning the process of science through narrative writing while enhancing student engagement in student-centered learning environments. This dissertation served as an initial step toward a long-term research agenda to investigate and advance the proposed Own it, Learn it, and Share it (OLSi) design framework. Particularly, I examined the role of autonomy, scaffolding, and a real world audience in a student-centered, college science course.

Key findings include the influence of endorsement and perceived task value on enjoyment with, and effort to complete, student-centered learning activities. Increased autonomy enables student freedom and choice, yet we still need to support psychological needs and sense of control over decisions and actions, perceived competence in potential ability and performance, and connections within the learning community. Well-designed scaffolds can support affective, cognitive, and behavioral engagement when crafted to support progression of individual needs. Generating and sharing learning artifacts for a real world audience also appear to influence engagement and extend opportunities for discussion and learning.

I encourage educators and designers to selectively apply the design guidelines suggested in Chapter 2 to promote truly student-centered learning and perhaps even to incorporate one or two student-centered learning activities. Student-centered learning can be implemented across different scales from individual activities, to classroom, to program, and to institution levels. However, different implementation scales will likely require careful consideration for both instructors and student participants. The design guidelines suggested in this dissertation only represents a micro level (i.e., activity) SCLE and may not applicable to a macro level.

However, this program of inquiry represents only an initial start toward addressing these challenges. DBR is typically a lengthy process involving multiple, iterative design cycles bridging analysis to design to evaluation and redesign to both refine an innovation in situ and reify underlying theoretical principles (Wang & Hannafin, 2005). The initial needs assessment and Spring 2013 implementations were featured. Though not detailed in this dissertation, an additional iteration of the refined design framework has been implemented in Spring 2014. The continued collaboration should further refine the OLSi framework and enable us to confidently suggest design principles applicable to broader contexts.

Autonomy, as a basic psychological need, should be supported in any human conditions including educational settings (Deci & Ryan, 2000). After testing and refining engagement design propositions in the context of college student-centered science learning, I plan to further examine the design propositions in broader contexts. Supporting autonomy of at-risk youths is an area of interest to me. Prior research indicated that autonomy support by teachers can enhance student engagement and reduce dropout rates (Fin & Rock, 1997).

Collaboration with a teacher from a “second-chance” high school with documented dropout issues may provide a unique venue for student-centered constructionist learning. Phoenix High School in Georgia, for example, offers students the opportunity to participate in a self-directed video production course during which the teacher supports autonomy, scaffolding, and addresses a real-world audience showcase. An agreement is established to continue my research in this setting. I would like to further investigate the power of autonomy with at-risk youths and refine the scaffolding propositions.

In addition, I plan to work with refugee youths to support school engagement and resettlement in the United States and to assimilate foreign culture within school systems and communities. Refugee adolescents have used Web 2.0 to reestablish ethnic ties and identity with the diaspora community as they build new identities as immigrants in the U.S. (Gilhooly & Lee, 2014). The influence of student-produced digital media for a real world audience on school engagement and resettlement has not been systemically investigated. This study will shed light on engaging English as foreign language learners through constructionist learning in formal and informal settings.

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APPENDICES

APPENDIX A. IRB CONSENT FORM

I, (Please write your name: _________________________________, agree to participate in a research study titled "The Effects of Autonomy, Guidance, and Real World Audience in Student-Centered Learning Environments" at the University of Georgia conducted by Eunbae Lee from the Department of Educational Psychology and Instructional Technology, The University of Georgia (611 Aderhold Hall, Athens, GA 30602; 706-286-5732) under the direction of Dr. Michael J. Hannafin from Department of Educational Psychology and Instructional Technology, University of Georgia (611 Aderhold Hall, Athens, GA 30602; 706-542-3157).

I understand that my participation is voluntary. I can refuse to participate or stop taking part at anytime without giving any reason, and without penalty or loss of benefits to which I am otherwise entitled. I can ask to have all of the information about me returned to me, removed from the research records, or destroyed. To withdraw from this study, I will contact the researcher via email or in person. I understand that the researcher will not ask any further questions regarding the reason of withdrawal. The investigator will answer any further questions about the research, now or during the course of the project.

The purpose of this study is to investigate the effects of autonomy support, guidance, and authentic audience on the quality of student learning artifacts and students' satisfaction with their learning experience and overall performance in undergraduate and graduate courses. If I volunteer to take part in this study, I may be asked to do the following things.

Please indicate your willingness to participate in each of the following by checking each item.

___________ I am willing to complete surveys.
___________ I am willing to participate in an interview and answer questions about my learning experiences. This interview will take approximately half an hour. The interviews will be audio taped.
___________ I am willing to give access to assignments I submit and grades I receive. This information will be confidential.

Again, this is completely on a voluntary basis. You may or may not choose to volunteer for any of the above-mentioned research activities. If you choose not to volunteer for any of the research activities at anytime, data with respect to you will not be collected and used for the research.

The benefits for me include that I can provide insight to the academic research community and society at large about effective measures and key strategies for improving student-centered learning and teaching practices. Findings from this study may prove useful in enhancing and creating student-centered learning and teaching practices.

No risk is expected but I may experience some discomfort or stress during the one-on-one, in-depth interview (if selected and agree to participate) as researchers in the room will be able to hear about my experiences. I can choose not to speak at any point during the study if I feel uncomfortable or otherwise do not choose to speak. I can opt out of filling out survey questions.

No individually-identifiable information about me, or provided by me during the research, will be shared with others without my written permission, except if required by law. I will be assigned an identifying pseudonym and this pseudonym will be used on all of the questionnaires I fill out.

I understand that the interview will be audio taped and transcribed. This recording will only be accessed by the two researchers (Eunbae Lee and Michael Hannafin). After transcription and analysis is completed on the video and audio recordings, these tapes will be destroyed.

I understand that I am agreeing by my signature on this form to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

_____________________________ _________________________________ _____________________

Name of Researcher Signature Date
Telephone: 706-286-5732
Email: leee@uga.edu

_____________________________ _________________________________ _____________________

Name of Participant Signature Date

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

APPENDIX B. 2012 ASSIGNMENT INSTRUCTIONS

Research Narrative

This is a new activity we are trying for the first time in 2012. This activity has three objectives. First, it is an opportunity for each student to familiarize themselves with a line of research and the people involved in that research. Second, it is a process by which some of you may identify prospective graduate mentors should you be interested in graduate studies in herpetology. Finally, there is mounting evidence that narratives are an excellent way to build an understanding of science as a process. Traditional science papers are organized in a manner to convey information concisely and clearly so that the methodologies and results can be critiqued and replicated. As such, the primary scientific literature is not necessarily effective at communicating research to a general audience, and it does not necessarily highlight the human process of scientific discovery. People are more accustomed to narratives [story telling] as a way of understanding how events build upon the sequence of prior events and the actors [protagonists] in those events. So, you will write a narrative describing the research of a person you identify.

Rules: (1) the person you write about cannot be a course instructor or guest instructor, and is preferably from an institution other than UGA, (2) you must be able to conduct 2-3 interviews with this person (by phone, Skype or in person), and (3) the person you will interview must be approved by the instructor and you must be able to demonstrate that you will be able to interview the person.

Make sure that you review the rubric for the narrative (attached to the back of the syllabus) in addition to reading the instructions below.

The scope of your narrative needs to address the following elements.

I. What is the big picture context of the research?
II. How did they arrive at their question or hypotheses?
III. What were the major theories or concepts that guided the research?
IV. What prior research [theirs or someone else's] was most influential in shaping their research?
V. Describe the research process. What exactly did they do in the various studies? What was the research experience like? Were there mistakes, adjustments, significant events, even funny stories?
VI. What do they think is most important about the research?
VII. What unexpected discoveries or questions came from the research?
VIII. What influence has the research had inside or outside that person's research program?
IX. What influence has the research had on their career or personal life or goals?

To get started, you should begin by searching for researchers by looking at references in your textbook and by using search engine with combinations of keywords of species, topics or locations that interest you. We have also provided a list of names and contact information for a number of awesome herpetologists on the course wiki.

Next, contact that person by email or phone call. It is common for people to overlook an email. Make sure you use a very professional email introducing yourself, your objectives, and providing some background on the assignment. Make sure you make them aware of your needs and deadlines. If you do not get a response, do not hesitate to follow up with a second or even third email, to call their office, or to call their department receptionist and have them deliver a message on your behalf. If, after reasonable persistence, you do not get a response, you will need to talk to select someone else. ***NOTE – non- responsive interviewees will not be considered a valid excuse for delays in completing your narratives.***
If you struggle to make contact with your interviewee, it is your discretion and responsibility to move on to another person.

Once you establish contact with your interviewee, discuss briefly with them the project you want to write about, and have them suggest 3 research papers for you to review in advance of your next interview.

Once you have finished reading the papers, you should conduct your second interview. This should be in advance of your first draft. For that interview, you should have a set of prepared questions to work through. At the end of that interview, request the names of some collaborators or graduate students you might also contact for information. End by scheduling a follow-up interview (after your first draft has been evaluated).

To prepare you narrative, review sample narratives provided on the course website. (Example: an article from the *National Geographic*)

APPENDIX C. 2012 RUBRIC

<table>
<tr><td>Name:</td><td></td><td>Point total:</td><td></td></tr>
<tr><td colspan="3">The Story (35%): The author effectively told a complete story as evidenced by…

1. the author grabbed the reader’s attention at the beginning and maintained interest throughout.
2. the author set the scene, developed characters, and used other elements of good story telling.
3. the author effectively engaged the reader by explaining a problem, drama, conflict, etc.
4. the story followed an arc (for example: rising action → climax → falling action) that made it recognizable as a story.</td><td></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="3">The Science (35%): The author effectively and accurately explained a scientific project as

evidenced by…

1. the author adequately and accurately explained the background information including key theories and concepts necessary for the target audience to understand the project and its significance.
2. the author clearly, accurately, and thoroughly explained for the target audience the science (concepts, key terms, key methodologies) without becoming mired in unnecessary details.
3. the author clearly stated and explained the rational and significance of the project to the target audience.</td><td></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="3">Overall Writing Quality (30%):

1. The writing style was easy to read (clear, concise and engaging).
2. The narrative was effectively organized as a whole.
3. Individual paragraphs were effectively organized.
4. Information [beyond the scientific information] was accurate.
5. The narrative was mostly free of spelling and grammatical errors and typos.
6. There was an overall professional effort.</td><td></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="3">Bonus Features: (up to 5% extra credit)

1. The author used elements, formats, or strategies that made the narrative particularly effective.</td><td></td></tr>
<tr><td colspan="4"></td></tr>
</table>

APPENDIX D. 2012 PEER REVIEW INSTRUCTIONS

There are several reasons why peer review is a valuable exercise. First, peer review is a fundamental part of how professionals communicate. Second, addressing reviewer comments helps with revision, and many authors agree that papers are ultimately improved by addressing the comments of reviewers. Third, serving as a peer reviewer improves your own writing. That is, we improve our own writing through opportunities to contrast it against what others do and do not do well.

The keys to being an effective peer reviewer are simple, (1) be a reader not an editor, (2) be honest, and (3) be constructive.

(1) Be a reader: Many of you have received essays or assignments from professors marked with tons of tiny writing in the margin or drawing your attention to typos and grammar issues. This is editing. It draws the writer's attention to fixing minor details, and does little to force the writer to revise. Revision is deconstructing, reorganizing and reconstructing an essay to make it more effective. When you read your peers' essays, do not dwell on minor issues like punctuation and grammar beyond noting whether there are sufficient grammatical problems to be distracting. Instead, read the essay for content and flow. Review the rubric and then ask yourself: was the essay well organized and did the author address all the required elements; did the author effectively develop a story; did the author effectively and accurately explain the science.

(2) Be honest: You do not help your colleague by blowing sunshine up their #!&*!. Don't take criticism of your writing personally, and be willing to give and except honest critiques. If an essay is awful, tell the writer it was awful. If you struggle with it, tell them you struggled with it. An author cannot know how much revision an essay needs if they do not honestly know how effective their essay is.

(3) Be constructive: Though it can at times be difficult, try and find both positive and negative things in your peers' essay. Criticism is inherently negative, so to be constructive it must be honest and inspiring. Search for things the author did well that they can use to model improvements throughout their essay. For example, if the writing is disorganized, but they managed all or part of a good paragraph, point that out. You can also suggest things that you would do [or did] that might help, such as suggesting where an example would help, or pointing them to an idea.

What to do today:

For today's peer review, exchange your essay with two peers. Read the essay and keep in mind the following questions:

1. Did the author effectively tell a complete story?
   a. Did the author grab the reader's attention at the beginning and maintain interest throughout?
   b. Did the author set the scene, developed characters, and used other elements of good story telling?
   c. Did the author effectively engage the reader by explaining a problem, drama, conflict, etc.?
   d. Did the story follow an arc (for example: rising action → climax → falling action) that made it recognizable as a story?
2. Did the author effectively and accurately explain a scientific project?
   a. Did the author adequately and accurately explain the background information including key theories and concepts necessary for the target audience to understand the project and its significance?
   b. Did the author clearly, accurately, and thoroughly explain for the target audience the science (concepts, key terms, key methodologies) without becoming mired in unnecessary details?
   c. Did the author clearly stated and explained the rational and significance of the project to the target audience?
3. Was the writing style easy to read (clear, concise and engaging).
4. Was the narrative effectively organized as a whole? Were individual paragraphs effectively organized?
5. Was information, other than scientific information, accurate?
6. Was there an overall professional effort? Was the narrative mostly free of spelling and grammatical errors and typos?
7. Did the author use elements, formats, or strategies that made the narrative particularly effective?

After you read the essay, complete a peer review sheet. Then return the students essay and exchange review sheets, and discuss your reviews. Remember to be honest and constructive. After you have completed the peer-review, flip over the review sheet you received from your partner, and answer the remaining questions.

Peer Review Sheet 1

1. What author's papers did you review?

2. What were the strengths of your essay compared to your peers' essays?

3. What were the weaknesses of your essay compared to your peer's essays?

4. What did you learn from reading a peer's essays that you might incorporate into your own essay?

Peer Review Sheet 2

Notes on peer’s paper	Reflective note

APPENDIX E. 2012 SELF-CRITIQUE INSTRUCTIONS

What to do for Tuesday, April 3 [in lab] – Self-critique:

Developing skills to critique and edit is a real challenge that even the more experienced writers struggle with their whole career. We will have you critique your own essay based on the comments of your peers, instructor comments, and your own reflection on the quality of your essay. This is a simple assignment, yet earns you 25 pts., and more importantly, should help you with your second essay later this term.

Critique write-up:

1. In 1 paragraph, describe the strengths of your narrative.
2. In 1 paragraph, describe the weaknesses of your narrative.
3. In 1 paragraph, describe a strength of a peer's narrative that you might use to improve your own.
4. Identify one poorly constructed or grammatically incorrect sentence in your essay. Write the sentence as it appears in the essay you submitted. Then, rewrite the sentence to be grammatically correct and more effective.
5. Identify and describe 1 typo or mistake from your essay.
6. Describe what activities you plan to do to revise your essay for the final draft.
7. List two strategies you could use to address the core weaknesses of your essay.

Critiques must be typed and submitted by 4 PM on Tuesday, April 3.

FAQ: Is it worth doing the critique? Yes! Think about it this way. We do not grade the critiques. They are for your personal benefit. If you do a reasonable job, you get 25 points. If you got a 75% on your essay (which is a pretty solid grade!), and you do not do the critique, your final grade on the first draft of the narrative is a 56/100 = 56%; however, if you do the critique, your final grade on Essay 1 is 81/100 = 81%. It's the difference between turning a C into an F or a B.

APPENDIX F. PRESURVEY

The First Day of Herpetology Class

1. I am

- ❍ Male.
- ❍ Female.

2. I am

- ❍ An undergraduate student.
- ❍ A graduate student.

3. I am _________ years old.

4. Have I ever taken a research method course?

- ❍ Yes
- ❍ No
- ❍ Do not know what that is.

5. Can I bring a laptop to class?

- ❍ Yes
- ❍ No
- ❍ Maybe

The following questions relate to your reasons for participating actively in the herpetology class. Different people have different reasons for their participation in such a class, and we want to know *how true* each of the reasons is for you. Please use the following scale to indicate how true each reason is for you:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

6. I will participate actively in the herpetology class:

	Circle one:
Because I feel like it's a good way to improve my understanding of the material.	1 2 3 4 5 6 7
Because others might think badly of me if I didn't.	1 2 3 4 5 6 7
Because I would feel proud of myself if I did well in the course.	1 2 3 4 5 6 7
Because a solid understanding of herpetology is important to my intellectual growth.	1 2 3 4 5 6 7

7. I will follow my instructor's suggestions for studying herpetology:

	Circle one:
Because I would get a bad grade if I didn't do what he suggests.	1 2 3 4 5 6 7
Because I am worried that I am not going to perform well in the course.	1 2 3 4 5 6 7
Because it's easier to follow his suggestions than come up with my own study strategies.	1 2 3 4 5 6 7
Because he seems to have insight about how best to learn the material.	1 2 3 4 5 6 7

8. The reason that I will work to expand my knowledge of herpetology is:

	Circle one:
Because it's interesting to learn more about the nature of herpetology.	1 2 3 4 5 6 7
Because it's a challenge to really understand how to solve herpetology problems.	1 2 3 4 5 6 7
Because a good grade in herpetology will look positive on my record.	1 2 3 4 5 6 7
Because I want others to see that I am intelligent.	1 2 3 4 5 6 7

9. How do I feel about the activities and projects listed in the syllabus?

	Very excited	Excited	Neutral	Not so excited	Not excited at all
Live classroom lectures	❍	❍	❍	❍	❍
Recorded online lectures	❍	❍	❍	❍	❍
Textbook readings	❍	❍	❍	❍	❍
Reading quizzes	❍	❍	❍	❍	❍
Midterm and final exams	❍	❍	❍	❍	❍
Lab exams	❍	❍	❍	❍	❍
Instructional lab	❍	❍	❍	❍	❍
Research narrative	❍	❍	❍	❍	❍
Amphibian inventory	❍	❍	❍	❍	❍

10. The research narrative project sounds like an important learning activity to me.

❍ Definitely True
❍ Probably True
❍ Neither True nor False
❍ Probably False
❍ Definitely False

11. I am excited about the "student-centered" nature of research narrative that I can interview someone who matches my interest and I can learn in a self-directed way.

❍ Definitely True
❍ Probably True
❍ Neither True nor False
❍ Probably False
❍ Definitely False

12. The syllabus states three objectives for the research narrative project. Rank each objective in the order of importance to me personally. 3 being the most important and 1 least important.

	3 Most important	2 Important	1 Least important
To foster a better understanding of science and the research process.	❍	❍	❍
To provide an autonomous [self-directed] activity that enables each student to relate this course to their personal interests in herpetology.	❍	❍	❍
To identify prospective graduate or career mentors.	❍	❍	❍

13. What would be my personal goal to achieve from this activity? (Check all that apply.)

❑ Understanding the general process of science

❑ Understanding the human side of conducting a scientific research

❑ Understanding a line of research conducted in the field of Herpetology

❑ Making connections with people in the field of Herpetology

❑ Identifying a potential graduate mentor for me.

❑ Becoming more interested in the field.

❑ Learning to communicate science with the general public

❑ Helping other people understand better about the field of Herpetology

❑ I will probably not gain anything.

❑ Other

14. If you have something particular you want to gain from the research narrative, please specify.

---

15. After I am done with the research narrative project, do I want to publish my narrative to the course wiki so others can read it?

❑ Yes

❑ No

❑ Not sure yet

Thank you for your participation.

APPENDIX G. POSTSURVEY

This survey is designed to solicit information about your motivation in participating in this Herpetology class and your experience with the research narrative. This survey is expected to take 20 minutes to complete it. The information you provide will be kept confidential and will not be associated with your name. Please respond honestly and thoroughly.

Your Herp ID (the one that identifies your grades in this course, not your 810): ______________
It is important that you provide your course ID to receive extra credit.

How would you rate your familiarity with the general process of conducting scientific research on a scale of 1 to 7?

Not familiar at all | Somewhat familiar | Very familiar

1	2	3	4	5	6	7

Compared to the beginning of the semester, your current knowledge of science as a field or endeavor has _________________.

a. Increased
b. Decreased
c. Remained about the same

As you reflect on the herpetology class this semester, how much did each of the following components of the course support your learning?

	Not Helpful	Somewhat Helpful	Very Helpful
Live Lectures	○	○	○
Reading Quizzes	○	○	○
Lecture Exams	○	○	○
Lab Practicals	○	○	○
Instructional Lab	○	○	○
Research Narrative	○	○	○
Amphibian Inventory	○	○	○
Field Trips	○	○	○

The following questions relate to your reasons for participating actively in this **Herpetology class**. Different people have different reasons for their participation in such a class. Now that you have completed the Herpetology class, we want to know *how true* each of the reasons is for you.

Please use the following scale to indicate how true each reason is for you:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

I participated actively in herpetology class:
(Please respond to each of the following items.)

	Circle one:
Because I felt like this class was a good way to improve my understanding of the material.	1 2 3 4 5 6 7
Because others might think badly of me if I didn't.	1 2 3 4 5 6 7
Because I would feel proud of myself if I did well in the course.	1 2 3 4 5 6 7
Because a solid understanding of herpetology is important to my intellectual growth.	1 2 3 4 5 6 7

I followed my instructor's suggestions for studying herpetology:
(Please respond to each of the following items.)

	Circle one:
Because I would get a bad grade if I didn't do what was suggested.	1 2 3 4 5 6 7
Because I was worried that I was not going to perform well in the course.	1 2 3 4 5 6 7
Because I found it easier to follow his suggestions than invent my own study strategies.	1 2 3 4 5 6 7
Because he seemed to have insight about how best to learn the material.	1 2 3 4 5 6 7

I worked to expand my knowledge of herpetology:
(Please respond to each of the following items.)

	Circle one:
Because I find it interesting to learn more about the nature of herpetology.	1 2 3 4 5 6 7
Because I find it a challenge to really understand how to solve herpetology problems.	1 2 3 4 5 6 7
Because a high grade in herpetology would look good on my record.	1 2 3 4 5 6 7
Because I wanted others to see that I am intelligent.	1 2 3 4 5 6 7

This questionnaire contains items that relate to your experience with your instructor in this class. Instructors can have different styles in dealing with students, and we would like to know more about how you feel about your encounters with your instructor. Your responses are confidential. Please be honest and candid.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

(Please respond to each of the following items.)

	Circle one:
My instructor provides me with choices and options.	1 2 3 4 5 6 7
I feel understood by my instructor.	1 2 3 4 5 6 7
My instructor conveys confidence in my ability to do well in this course.	1 2 3 4 5 6 7
My instructor encourages me to ask questions.	1 2 3 4 5 6 7
My instructor listens to how I like to do things.	1 2 3 4 5 6 7

Now, let's talk specifically about the research narrative project.

To what extent do you feel you have achieved each of the following through the research narrative project on a scale of 1 -7?

	Did not achieve	Somewhat achieved	Fully achieved
Understanding the general process of science	○	○	○
Understanding the human endeavor of conducting scientific research	○	○	○
Understanding a line of research that was conducted in the field of herpetology	○	○	○
Making connections with people in the field of herpetology	○	○	○
Identifying a potential graduate or career mentor	○	○	○
Becoming more interested in scientific research	○	○	○
Helping others better understand the value of herpetology	○	○	○
Learning to communicate science through writing for the general public	○	○	○

Now that you have completed the research narrative project, please indicate how true each of the following statements is for you using the following scale:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

Circle one:

I enjoyed doing this activity very much.	1	2	3	4	5	6	7
I put a lot of effort into this.	1	2	3	4	5	6	7
This activity was fun to do.	1	2	3	4	5	6	7
While I was doing this activity, I was thinking about how much I enjoyed it.	1	2	3	4	5	6	7
I believe I had some choice about how to do this activity.	1	2	3	4	5	6	7
I believe that doing this activity is useful for learning science.	1	2	3	4	5	6	7
I prefer not to interact with the researcher in the future.	1	2	3	4	5	6	7
I did not try very hard to do well at this activity.	1	2	3	4	5	6	7
I believe doing this activity could be beneficial to me.	1	2	3	4	5	6	7
I would like a chance to interact with the researcher more often.	1	2	3	4	5	6	7
I did not put much energy into this activity.	1	2	3	4	5	6	7
I did this activity because I had no choice.	1	2	3	4	5	6	7
I think this is an important activity.	1	2	3	4	5	6	7
I feel close to the researcher.	1	2	3	4	5	6	7
I did this activity because I wanted to.	1	2	3	4	5	6	7

How difficult did you find each of the following while you worked to complete the **research narrative** project?

	Not Difficult	Moderately Difficult	Difficult
Understanding why this assignment was beneficial to me	◯	◯	◯
Identifying a researcher or a topic who matched my interest	◯	◯	◯
Contacting a researcher to interview	◯	◯	◯
Interviewing a researcher	◯	◯	◯
Searching for information about the topic or the researcher	◯	◯	◯
Searching for the scholarly article of my researcher	◯	◯	◯
Understanding the research I described in my narrative	◯	◯	◯
Understanding the scientific journal articles	◯	◯	◯
Deciding which content to include in my narrative	◯	◯	◯
Blending science into a story	◯	◯	◯
Writing a creative story	◯	◯	◯
Conveying scientific knowledge to a layperson	◯	◯	◯

What other things did you find challenging while you worked to complete the research narrative project?

___

___

___

How would you rate the helpfulness of the following in assisting you in the completion of the Research Narrative project?

	Did not use	Not helpful	Somewhat helpful	Very helpful
Instructions provided in the syllabus	○	○	○	○
Rubric	○	○	○	○
Keywords Icebreaker	○	○	○	○
Researcher Profile	○	○	○	○
Optional Research 101 workshop	○	○	○	○
Story writing guidelines that Eunbae posted on the course website and on Facebook	○	○	○	○
One-on-one writing tutoring with Eunbae	○	○	○	○
Professional examples	○	○	○	○
Peer review	○	○	○	○
Instructor's written feedback on the first draft	○	○	○	○
Self-critique	○	○	○	○
Cover letter	○	○	○	○
Opportunity to revise	○	○	○	○

Who did you choose as your target audience?

a. Children
b. Adolescents
c. Lay audiences
d. Peer students
e. Professionals
f. Other Please specify: ____________________________________

Describe how your research narrative was written to be appropriate for your target audience. (How did you make it appropriate? Give as many details as you can.)

What was your choice for publication?

a. Not publish at all
b. Publish on the course website
c. Publish on Living Alongside Wildlife
d. Publish on Life is short, but snakes are long.
e. Other Please specify: ____________________________________

If you chose to publish, did having to publish at a public site make you put more effort into your narrative?

a. Yes
b. No
c. Does not apply

If you chose to publish, what was the reason?

If you chose NOT to publish, what was the reason?

How many times did you interview your researcher or others for your narrative (including follow up phone calls and emails)?

a. 0
b. 1
c. 2
d. 3
e. More than 4 times

Where did you get most of the information for your story?

a. From the interviews with the researcher
b. From the researcher's scholarly articles
c. About equally from both the interviews and the articles
d. Other (Please specify: ___________________________________)

Which tools did you use to obtain information for your story? (Check all that apply.)

- ❑ Web search engines (such as Google)
- ❑ Google Scholar
- ❑ Web of Science
- ❑ UGA library database
- ❑ Other Web resources on the topic
- ❑ Researcher's personal blogs
- ❑ Researcher's personal websites
- ❑ Researcher's affiliated institutions' websites
- ❑ News media (Magazines, Newspapers, Internet news, Television)
- ❑ Other (Please specify: _______________________)

This is the end of the questionnaire. Thank you for your time and participation.

APPENDIX H. STUDENT INTERVIEW PROTOCOL

Semi-structured interview

Dates: April 22- May 3, 2013

Interviewer: Primary researcher, Eunbae Lee

Participants: 20 students from Herpetology

Location: Aderhold 611

Duration: 60 minutes

Goals for Interview

1. Address the research questions.
    a. Make sure what students achieved versus what the instructor intended for them?
    b. Learning the process of science
    c. Effectiveness of each scaffolding activity

Icebreaker

Overall experience	• Can you walk me through the process you used to complete the research project from beginning to end?

Own it

Endorsement	• What was the goal of this activity? (What was the instructor's intention for requiring this activity in this class?) • Was it a valuable activity for you?
Personal relevance	• Did you have anything you wanted to achieve personally through this activity? (Were you trying to achieve any personal goal from the RN?: "Nothing")
Keyword activity	• You had to come up with the keywords that represent your interests. What were they? • How did the keyword activity help you identify the person for your story?

Learn it

Literature Search	• Can you walk me through (Describe) the process that you used to learn about the researcher's work?
	• Did you read any primary science papers written by the researcher (clarify what primary science papers)?
	• Did you use any other resources related to the topic? (papers by others, blogs, Wikipedia, etc)
	    o Yes:
	        ▪ How and where did you find them?
	        ▪ How did you find interpreting the primary papers?
	    o No:
	        ▪ What was the reason for not using the primary papers?
	            • Did you come to Research 101?
	    o Did not come: What was your reason for not coming?
	    o Came: What were you hoping to gain from the workshop?
	• How was it? How did it help you?
	• How would you make it better?

Interview	• Did you interview anyone to write your story? Who did you interview?
	    o Yes
	    ▪ Who did you interview?
	    ▪ What was it like to talk with your researcher? (Describe the atmosphere)
	    ▪ What questions did you ask?
	    ▪ Did you follow up? What questions did you ask during follow up?
	    ▪ What would you do differently to help you prepare for the interview?
	    ▪ Do you think you can contact him or her again to seek advice?
	    o No: Why not?
	• Do you have any suggestions to give to the instructor that would have helped you better prepare for conducting interview?

Share it

Writing the first draft	• What was it like for you to write a narrative compared to science report? • Describe the process of how you wrote the narrative? (take the content and turn it into a story? How did you write the story?) • How did you compare writing a narrative to writing a typical science report? • Who was your target audience? • What did you do to make your story appealing to your target audience? • How did you go about communicating science? • What was it like for you to translate scientific terms to plain English (Did it reinforce students to truly engage in the concept and learn deeply and remember for a longer time)?

Writing guidelines	• Did you use the writing guidelines that I posted?
	    o If yes, how did they help you?
	    o If no, why not?

Peer review	• What was it like for you to do the peer review? • What did you learn from the peer review?
Self-critique	• Did you submit the self-critique to Dr. Maerz? • In your self-critique, what did you describe as how you would change your narrative?
Revisions	• What was the instructor's feedback on your first draft? • Did you incorporate the feedback from the peer and the instructor final draft? • How? In what respect?
Cover letter	• What did you write in your cover letter? • Did students find it busy work? Or did it really help?

Publications	• Did you choose to publish?
	    • How did it influence your participation in it?
	    • Did you put more effort into since you published it?

Overall process

Student experience	• What did you enjoy about the project? • What did you not enjoy? (e.g., browsing for potential interviewees, exploring the researcher's work on your own, interviews, creative writing, reading other's narratives, revisions, publishing) • There were a lot of steps you were required to do part of the research narrative. What was actually helpful and what was not?
Goal achievement	• What did you learn from doing the research narrative project? o (Did students learn the process of science?) • Please tell me more specifically about what it is that you learned in this class about science as a field.
Recommendations	• What advice would you give to future students? • How would you change this assignment for students in the future?

APPENDIX I. 2013 ASSIGNMENT INSTRUCTIONS

Research Narrative – *This is a relatively new activity first implemented in 2012. We have adjusted the assignment based on student feedback and may require additional adjustment as the semester progresses*. This activity has three objectives. The primary objective is to use current research in herpetology to foster a better understanding of science and the research process. The second objective is to provide an autonomous [self-directed] activity that enables each student to relate this course to their personal interests in herpetology through the exploration of a specific line of research and the people involved in that research. Finally, for those students interested in careers in herpetology, the research narrative process is a means to identify prospective graduate or career mentors.

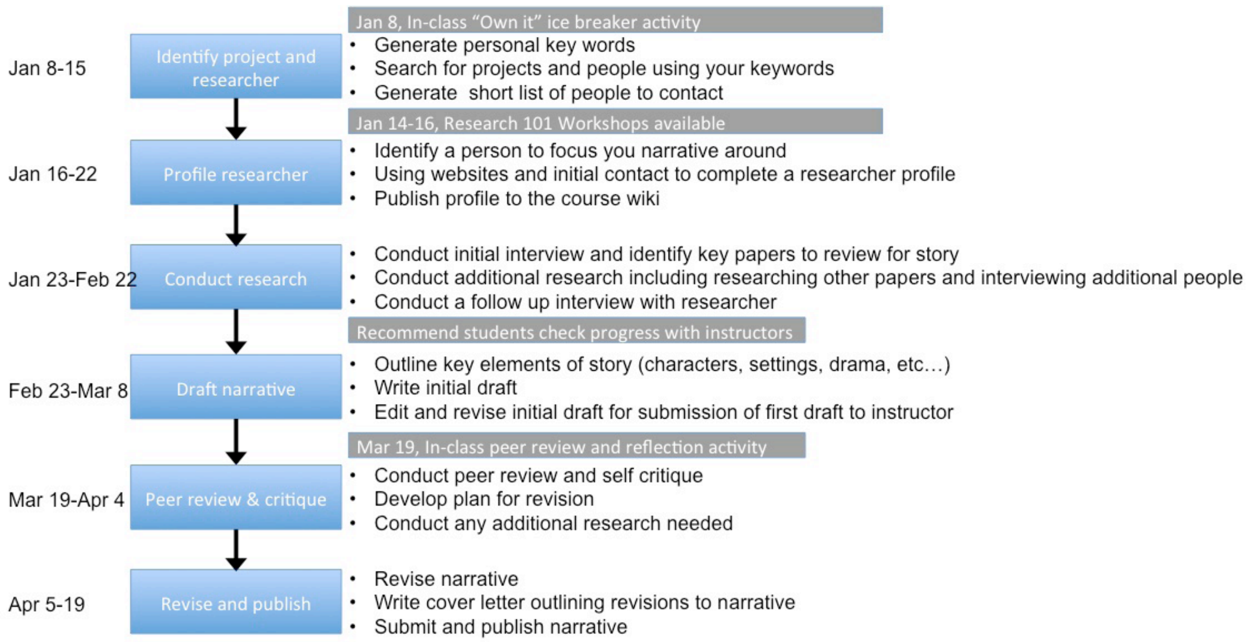
<u>So what is a narrative and why a narrative as opposed to a traditional research paper?</u> There is mounting evidence that narratives are an excellent way to build an understanding of science as a process. Traditional science papers are organized in a manner to convey information concisely and clearly so that the methodologies and results can be critiqued and replicated. As such, the primary scientific literature is not necessarily effective at communicating research to a general audience, and it does not necessarily highlight the research process and human endeavor of scientific discovery. People are more accustomed to narratives [story telling] as a way of understanding how events build upon the sequence of prior events and the actors [protagonists] in those events. So, rather than write a traditional research paper, you will write a story about a research project and a person you identify.

Rules: (1) the person you write about cannot be a course instructor, and is preferably from an institution other than UGA, (2) you must be able to conduct 2-3 interviews with this person (by phone, Skype or in person), and (3) your instructors must approve the person you will profile. Note, you accept full responsibility for communicating with your interviewee, and non-responsive interviews will not be considered a valid excuse for late or incomplete work. We strongly recommend you select someone with whom you have made contact and have arranged availability to interview.

This is an autonomous activity that requires your attention throughout the semester; however, we will provide you structured guidance and support throughout the semester including clear milestones and structured activities (see chart below). *Make sure that you review the rubric for the narrative.* You should also review the example narrative on the course website.

Research 101 Workshop

In support of your research narratives, we will offer an elective, 1 hour workshop demonstrating various strategies to go about understanding the research project you highlight in your narrative. We will go over how to identify and access primary literature, how to conduct an interview, and how to identify and integrate different research elements.



Grading Guidelines

Core Requirements	Points	Due date
Profile	20	January 22
Draft 1	75	March 8
Peer review and critique	25	March 25
Draft 2 with cover letter	100	April 19

APPENDIX J. 2013 RUBRIC

The Science (50%): The author effectively explained a scientific project as evidence by...

1. adequately and accurately explaining the background information necessary for the target audience to understand the larger context and significance of the project including the theoretical and applied concepts at the core of the project and the study system.

2. accurately and thoroughly guiding the reader through the development of the project, how the actual work was conducted including details of approaches, and how data was collected and ultimately interpreted.

3. clearly explaining the significance of the project's findings and how the project has advanced our scientific understanding [what's next?].

4. writing with sufficient explanation for **the target audience** to understand the project and its importance.

The Story (30%): The author effectively told a complete story as evidenced by…

1. following an arc (for example: rising action, climax and falling action) that made it recognizable as a story instead of a report.

2. engaging the reader by explaining a problem, creating compelling drama or conflict, and providing resolution.

3. consistently setting scenes, developing characters (people, animals, other things), and using other elements of good story telling.

Overall Writing Quality (20%):

1. Was the writing style easy to read (clear and engaging).
2. Was the narrative effectively organized as a whole?
3. Were individual paragraphs effectively organized?
4. Was information, other than scientific information, accurate?
5. Was the narrative mostly free of spelling and grammatical errors and typos?
6. Was there an overall professional effort?

Bonus Features: (up to 5% extra credit)

1. Did the author use elements, formats, or strategies that made the narrative particularly effective?

APPENDIX K. 2013 PEER REVIEW INSTRUCTIONS[5]

There are several reasons why peer review is a valuable exercise. First, peer review is a fundamental part of how professionals communicate. Second, addressing reviewer comments helps with revision, and many authors agree that papers are ultimately improved by addressing the comments of reviewers. Third, serving as a peer reviewer improves your own writing. That is, we improve our own writing through opportunities to contrast it against what others do and do not do well.

The keys to being an effective peer reviewer are simple, (1) be a reader not an editor, (2) be honest, and (3) be constructive.

1. Be a reader: Many of you have received essays or assignments from professors marked with tons of tiny writing in the margin or drawing your attention to typos and grammar issues. This is editing. It draws the writer's attention to fixing minor details, and does little to force the writer to revise. Revision is deconstructing, reorganizing and reconstructing an essay to make it more effective. When you read your peers' essays, do not dwell on minor issues like punctuation and grammar beyond noting whether there are sufficient grammatical problems to be distracting. Instead, read the essay for content and flow. Review the rubric and then ask yourself: was the essay well organized and did the author address all the required elements; did the author effectively develop a story; did the author effectively and accurately explain the science.

2. Be honest: You do not help your colleague by blowing sunshine up their #!&*!. Don't take criticism of your writing personally, and be willing to give and except honest critiques. If an essay is awful, tell the writer it was awful. If you struggle with it, tell them you struggled with it. An author cannot know how much revision an essay needs if they do not honestly know how effective their essay is.

3. Be constructive: Though it can at times be difficult, try and find both positive and negative things in your peers' essay. Criticism is inherently negative, so to be constructive it must be honest and inspiring. Search for things the author did well that they can use to model improvements throughout their essay. For example, if the writing is disorganized, but they managed all or part of a good paragraph, point that out. You can also suggest things that you would do [or did] that might help, such as suggesting where an example would help, or pointing them to an idea.

[5] This peer review instructions are repeated from the previous year.

APPENDIX L. 2013 SELF-CRITIQUE INSTRUCTIONS[6]

What to do for Tuesday, March 18 [in lab] – Self-critique:

Developing skills to critique and edit is a real challenge that even the more experienced writers struggle with their whole career. We will have you critique your own essay based on the comments of your peers, instructor comments, and your own reflection on the quality of your essay. This is a simple assignment, yet earns you 25 pts., and more importantly, should help you with your second essay later this term.

Critique write-up:

1. In 1 paragraph, describe the strengths of your narrative.
2. In 1 paragraph, describe the weaknesses of your narrative.
3. In 1 paragraph, describe a strength of a peer's narrative that you might use to improve your own.
4. Identify one poorly constructed or grammatically incorrect sentence in your essay. Write the sentence as it appears in the essay you submitted. Then, rewrite the sentence to be grammatically correct and more effective.
5. Identify and describe 1 typo or mistake from your essay.
6. Describe what activities you plan to do to revise your essay for the final draft.
7. List two strategies you could use to address the core weaknesses of your essay.

Critiques must be typed and submitted by 4 PM on Tuesday, April 3.

FAQ: Is it worth doing the critique? Yes! Think about it this way. We do not grade the critiques. They are for your personal benefit. If you do a reasonable job, you get 25 points. If you got a 75% on your essay (which is a pretty solid grade!), and you do not do the critique, your final grade on the first draft of the narrative is a 56/100 = 56%; however, if you do the critique, your final grade on Essay 1 is 81/100 = 81%. It's the difference between turning a C into an F or a B.

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[6] Self-critique instructions are repeated from the previous year.

APPENDIX M. PARTICIPANT OBSERVATION PROTOCOL

Observation Date: ____________________ Observer: ____________________

Start time: ________________ End time: ____________________

Class number: _________________

Classroom: ____________________

Instructor: _______________

Number of students: ____________________

1. Describe the project that students are working on.

2. What are students doing?

    a. Is it a group work or an individual work?

    b. How are students interacting with other students?

3. What is the instructor doing?

4. What does instructor do to help students understand and perform the project?

5. What does the instructor do to identify difficulties students experience and to address the difficulty?

6. What kind of autonomy support scaffold does the instructor use or not use?

7. What kind of autonomy support language does the instructor use or not use?

APPENDIX N. 2013 KEYWORD ICEBREAKER TEMPLATE

Name:________________________________

List three herp taxa that interest you:	List three places of interest to you:
1.	1.
2.	2.
3.	3.

Conservation Biology

List three personal interests that you have:	List three career interests that you have:
1.	1.
2.	2.
3.	3.

APPENDIX O. DATA ANALYSIS MATRIX

Research Question 1	**How do research narratives influence learning science processes?**			
Specific questions	**Assumptions**	**Data sources**	**Analysis**	**Result**
What effects do research narratives have on student's learning the processes of science in college-level, student-centered science learning environments?	Through the research narratives, • Students gained understanding of the processes of science. • Students developed skills to communicate with the general public in writing. • Students developed connections with other researchers and scientists.	Score differences on the first draft and final draft on Science. Some students did not revise their first draft therefore the score remains the same from the first draft to final draft. Student interviews	Descriptive Statistics Thematic analysis of interviews	Student interviews revealed that students did not focus on learning the processes of science through the research narrative. Students were more concerned about writing a story and conveying scientific information to a lay audience.
How did the scaffolding activities in the OLSi model help students' engagement and performance on the research narrative?	Keyword activity: Identifying topics Research 101: Research methods and contacting and interacting with researcher Story writing guidelines: Helped with storywriting Peer review: Encouraged revision and enhanced scores Self-critique: metacognitive Cover letter: metacogntive	Post survey	Descriptive Statistics	Instructor's written feedback on the first draft Opportunity to revise Peer review Self-critique Rubric Instructions Research 101 workshop Researcher Profile
How did students perceive the research narrative project?	Students perceived the narrative was useful and relevant activity for this course (e.g., learning the processes of science).	Interviews Postsurvey – Goal achievement, Useful guidance, difficulty Intrinsic Motivation Inventory- Enjoyment, perceived choice, perceived competence,	Thematic analysis of student interviews The rank order of helpful class component	Research narrative was voted as the least helpful class component. Student perceptions vary. Students who positively perceived the research narrative, demonstrated higher engagement.
What else did students experience while working on the narrative?	Learning the course content	Student interviews	Thematic analysis of student interviews	Popular science writing is a great way of public engagement.

Research Question 2	**To what extent do autonomy support, scaffolding and real-world audiences influence engagement and performance in college-level, student-centered science learning environments?**			
Specific questions	**Assumptions**	**Data sources**	**Analysis**	**Result**
How does engagement factors affect students' performance in the research narrative?	Students who engaged deeply in the research narrative performed at a higher level.	IMI and research narrative final scores	Regression Principal Component Analysis – SEM (Not appropriate for this study due to the limited number of participants)	Engagement has a very significant effect on performance. Effort, value, and enjoyment had a significant influence in student engagement.
How does students' perceived autonomy support from the instructor influence student's engagement and performance in the research narrative?	Students who perceived that they had autonomy in the course were better engaged and better performed.	Students PCI score (Maybe include Choice score?) Engagement component Research narrative performance score	Regression	PAS had no significant effect on engagement or performance.
How does writing for publications (real world audience) influence student's engagement and performance in the research narrative?	Students who determined to publish their narrative in the blog for a real world audience were better engaged and better performed.	Students' choice of publications for real world audiences Engagement component Effort (IMI) score Research narrative performance score	One way between subject ANOVA (3x1)	Students who decided to publish their stories on the external blog showed a significantly high engagement (p=.07) and but not in performance. Audience and Choice variables significant (p=.09) Audience and PAS not significant

APPENDIX P. EXAMPLE OF QUALITATIVE ANALYSIS

Category: Own it scaffold: Elements of Own it scaffold which affect positively or negatively the participants' engagement, performance, and improvement				
Cluster	Definition	Codes	Definition	Example
Endorsement /Value	Use this code when the participants endorse value of the research narrative	Public outreach	Use this code when participants discuss engaging the public	"I think it was really good to learn how to write a paper like this because when you're trying to educate the public about a certain thing, you can't just educate somebody with throwing scientific facts at them like a typical research paper would"
		Writing in a different form	Use this code when participants discuss the value of writing in a different form	"I feel like the most important part for the grad students was learning how to write popular science articles because we're so stuck in that scientific journal, get as many articles published as possible mindset that we don't write as much outside of that and so I feel that's very useful for us"
		Networking	Use this code when participants value networking opportunities	"I guess I really enjoyed getting the experience to kind of work on reaching out to other people ... I knew that could be critical for a future job"
Personal Goals	Clusters of personal goals students established for themselves	Content, networking, writing	Use this code when participants specify content learning, networking, and writing	"To learn more about endocrine structures and to get to know Lou Hernandez and to practice science writing"
		Lack of personal goal	Code when participants lack personal goals	"Mostly I had to turn this in to get a grade."
Choice/ Flexibility	Clusters of choice or flexibility about the research narrative	Choice	Use this code when participants discuss choice	"I felt like it was better because I could choose I wanted to go to and so nothing was really forced."
		Connecting topic to passion	connection between their interest and the topic of the research narrative	"Everybody probably wrote about something they generally love and are interested in and that's probably the best part of it."

Category: Learn it scaffold: Elements of Learn it scaffolding which affect positively or negatively the participants' engagement, performance, and improvement				
Cluster	Definition	Codes	Definition	Example
Learning the process of science	Clusters of participants discuss learning the process of science	Positive/ weak about learning the process of science	Use this code when participants are positive but not certain about learning the process of science	"I don't know if that really applies to me (laughs) but I don't…it did a bit (learned the process of science), I guess…because I got to learn about what goes into it so that was cool, talking to her about those…so I guess, yeah" "this kind of assignment I think is good for growth in terms of like expanding the knowledge scientifically"
Scaffolding activities	Clusters of participants' experience in scaffolding activities (keyword icebreaker, Research 101, story writing prompts, Peer Review)	Negative about keyword icebreaker	When participants discuss keyword icebreaker negatively	"To be honest with you, it almost hindered me. ... I got stuck with this behavior thing."
		Positive on researcher profile	When the participants discuss researcher profile positively	I think he did a good job of making us do the researcher profiles because that's started it all. I used a majority of the information on a researcher profile in my paper."
		Positive about Research 101	When the participants discuss Research 101 positively	"Research 101 helped me a lot and gave me some people to try and look at."
		Positive about Peer Review	When the participants discuss peer review positively	"we were all thinking in our minds when we were looking at somebody else's paper was, "Well, I did this better than they did and so I'll just write that down, that they didn't do this well because I feel like I did mine correctly" kind of thing"
		Negative about self-critique	when the participants discuss cover letter negatively	"I feel like the self critique was just me saying what everybody else had just told me."
		Negative about cover letter	when the participants discuss cover letter negatively	"I felt like that was kind of pointless, too, because I just feel like it was an extended version of the self critique."

Category: Share it scaffold: Elements of Share it scaffolding which affect positively or negatively the participants' engagement, performance, and improvement				
Cluster	Definition	Codes	Definition	Example
Audience	Clusters of target audience-related discussions	Real world audience	Use this code when participants discuss their attitude toward publishing for real world audience	"It made me work harder because I knew that other people were going to be reading it, it wasn't just going to be me and Dr. Hertz and potentially Jacob, it was going to be tons of other people."
		Communication of scientific terms to lay audience	Use this code when participants discuss how and what they did to make scientific terms understandable to target audience	"I felt like I didn't need to explain certain things but when it came to evolution, okay, I'd take a break and explain what it is. And so they fully understand how that relates to what's going on…"
Publication	Clusters of publication-related discussions	Positive about publication	Use this code when participants show positive attitude toward publishing	I think that's great experience. I think it's cool. The idea of having published work even though it's not like a big deal where I'd be publishing it. I think it would be cool to have my writing, my thoughts, my feelings out on like this public website that anybody can read."
		More efforts	Use this code when participants discuss putting more effort in anticipation of publication	I took Dr. Hertz's comments more seriously than I would have had I not wanted to publish it. I took the whole paper in general more seriously. And in some terms I'd say it was good for me that I did decide (to publish) because otherwise I probably would have not put forth as much effort as I did."
		Publication concerns	Use this code when participants display concerns about publishing	I could keeping it in the limits of the website that I wanted to publish it in. Turns out that was a huge issue because it was far too short and I didn't include nearly as much information as I needed to.

APPENDIX Q. RESEARCH PROCEDURE AND SCAFFOLDING ACTIVITIES

Stage	Research Procedure	Date	Activity objective	Scaffolding prompts	Course activity and scaffolding	Deliverables
Own it (Developing autonomous motivation)	Introduction of research Participation recruitment Consent	Day 1	Understand the requirement of the activity	• What is this research narrative project all about?	• Introduction by the instructor • Syllabus • Rubric • Examples	Signed consent form
	Presurvey (Own it, SRQ)	Day 1	External goal endorsement	• The syllabus states three objectives for the research narrative project. Rank each objective in the order of importance to me personally. • The research narrative project sounds like an important learning activity to me. • I am excited about the "student-centered" nature of research narrative that I can interview someone who matches my interest and I can learn in a self-directed way.	• Rationale verbal and written explanation by the instructor	
		Day 1	Personal goal setting	• What would be my personal goal to achieve from this activity? (Check all that apply.) • If you have something particular you want to gain from the research narrative, please specify.	• Possible gains stated in presurvey	• Personal goals selected in presurvey
	Observation	Day 1	Self-knowledge of personal interests	• What am I interested?	• Keyword icebreaker	• Keywords
	Publication choice	Week 1	Identification of publication choice	• Who are my audiences? • Do I want to publish? If so, where?	• Target audience and publication venue	• Audience choice

Learn it (Student-centered inquiry)	Research 101 observation	Week 2 - 7	Conduct Research	• What would I want my story to be about? • How do I search information about this topic? • What is the research about? • What are the findings? • What are the implications for the field?	• Research 101 (How to Google Scholar)	•Researcher profile
			Conduct interview	•How do I find a researcher I can interview? •What questions do I want to ask among the sample questions? • What do I want to hear directly from this researcher? • Is there anything I want to clarify from other sources?	• Research 101 (How to approach potential interviewee) • Possible interview questions	
Share it (Writing for target audiences)	First draft scores	Week 9 (Due)	Write first draft	• Who are my audiences? • How to communicate science as story to my audiences?	• Story writing guidelines • One-on-one story writing consultant	• First draft
	Peer review observation	Week 11 Week 13	Peer review and self critique	• Give feedback • Receive feedback • Self- critique	• Peer Review • Self-critique templates	• In-class peer review • Self-critique
	Post survey Student interview Final draft scores	Week 15	Revise and publish	Incorporate feedback Submit to the instructor and for publication	• Instructor feedback	• Cover letter • Final draft

APPENDIX R. 2013 STORY WRITING GUIDELINES

Guidelines for Turning Your Content into a Story

By now you must have profiled a researcher and interviewed your researcher. You should have 1-2 academic papers written by his or her research group. Now all you need to do is to write a story.

Are you stuck? You just don't know how to turn the content into a story?

Think about and answer the following questions:

1. **<u>Have you read the rubric for the research narrative assignment?</u>**
   If you haven't done so, you might want to do that first. I will grade your first draft based on the criteria shown in the rubric. Did you notice that there is a science part, a story part, and a writing part? So make you sure you address all the things on the rubric.

   Note that the science portion makes up 50% of your grade. You need to talk about the background on how the researcher came up with the research question, what other previous research talks about the research topic as well as the theory, methods of research, analysis of data, findings, and impact (significance) of the study. You should be able to find out this information from the academic papers and from the interviews with your researcher.

2. **<u>Then, how do you transform all the science information into a story?</u>**
   b) What is the message you want your readers to receive by reading your story?

   c) Who is telling the story?
   That is, through whose voice are you telling the story? Is it the researcher? Is it you (narrator) who is telling the story of the researcher? Is it an organism? You can be really creative with this.

   d) Who is going to read your story?

   e) What is the setting?

   f) Who is the protagonist?

   g) Who or what is the antagonist?
   Think broadly about this. Could it be a person who disagrees intellectual, conflict between theories, public ignorance, industry, politics?

   h) Are there any supporting characters?
   Again, think broadly about this.

   i) What is the drama [conflict or the crisis]?
   Every story has a conflict. People are not interested in all happy, all smooth sailing

stories. There should be an event or a series of events that represents crises, pitfalls, and unexpected problems. All super heroes fight against a villain and resolve a conflict. Every story follows an arc (rising action – crisis – falling action).

j) How would you set the scene leading up to the conflict?
This MIGHT be a place to talk about background information, theory, research questions, data testing methods and analysis of the data.

k) What happened during the crisis (or at the climax)?

l) How was the conflict resolved? Who did what?
You may talk about results of the research, findings and the impact of the research.

m) How would you end the story?
Is it a happy ending? Are there any remaining issues? Try to avoid ending predictably as long as you stick with the truth.

APPENDIX S. 2014 ASSIGNMENT INSTRUCTIONS

Herpetology Popular Science Story – *This is a relatively new activity first implemented in 2012. We have adjusted the assignment based on student feedback and may require additional adjustment as the semester progresses*. This activity has three objectives. The primary objective is to use current research in herpetology to foster a better understanding of science and the research process. The second objective is to provide an autonomous [self-directed] activity that enables each student to relate this course to their personal interests in herpetology through the exploration of a specific scientific topic and the people involved in that research. Third, this is an opportunity to hone your communication skills through communicating issues and scientific concepts to a general audience.

<u>So what is a popular science story, and why a story as opposed to a traditional research paper?</u>

There is considerable evidence that the human brain is adapted to stories. We are naturally accustomed to story format, which is why oral and written stories are at the heart of most human cultures. Stories build understanding by building upon a sequence of events and the actors [protagonists] in those events. This awareness has transferred to how we think about learning and communicating in the sciences. Telling and reading stories are a potentially more effective and engaging way to build an understanding of science as a process. I am sure most of you have read or watched a popular science story as a means to learn more or be inspired about a topic. So, rather than write a traditional research paper, you will tell a story about a topic and the underlying science related to herpetology. This year we are allowing students the option to write a story or produce a 31/2 - 5 min digital story. You are free to choose any topic or system that interests you; however we require that all stories include commentary or material stemming from an interview with a person working in herpetology [and is not a course instructor]. Your goal is to write or produce a story that is published publicly through the course website.

This is an autonomous activity that requires your attention throughout the semester; however, we will provide you structured guidance and support throughout the semester including clear milestones and structured activities (see chart below).

Make sure that you review the rubric for the story. You should also review the example narrative on the course website.

Story Planning and Research 101 Workshop

In support of your research narratives, we will offer an elective, 1-hour workshop demonstrating various strategies to identifying important elements for your story, planning your story, identifying and accessing primary literature, conducting interviews, and integrating science into stories.

Grading Guidelines

Core Requirements	Points	Due date
Sample story and video	10	January 16
Draft story or script	50	February 27
Draft critique and plan	10	March 25
Final story/video with cover letter	100	April 24

APPENDIX T. 2014 RUBRIC

Herpetology (WILD/ECOL 4040/6040) Popular Science Story Rubric

The Science (45%): The author effectively explained a scientific topic and project as evidence by...

1. adequately and accurately explained the background information necessary for a general audience to understand the larger context and significance of the topic and project including the theoretical and applied concepts at the core of the project and the biology of study system.
2. accurately and thoroughly guided the reader through the development of a specific project related to the larger topic. The author clearly described/illustrated how the actual work was conducted including details of approaches, and how data was collected and ultimately interpreted.
3. clearly explained the significance of the project's findings and how the project has advanced our scientific understanding [the audience will know what needs to happen next?].
4. told the story with sufficient detail and clarity for **the target audience** to understand the science behind the issue and the specific project so as to recognize their importance.

The Story (25%): The author effectively told a complete story as evidenced by…

1. following an arc (for example: rising action àà climax àà falling action) that made it recognizable as a story instead of a report.
2. engaging the audience by explaining a problem, creating compelling drama or conflict, and providing resolution.
3. consistently and effectively setting scenes or using visuals, developing characters (people, animals, other things), and using other elements of good story telling.

Overall Writing/Video Quality: (20%)

1. Was the writing or video narration clear and engaging.
2. Was the story effectively organized as a whole?
3. Were individual paragraphs or sections of the video effectively organized?
4. Was information, other than scientific information, accurate?
5. Was the story or narration mostly free of spelling and grammatical errors?
6. Was there an overall professional effort?

Additional Required Elements: (10%)

1. The story included adequate content derived directly from interviews with at least one expert.
2. The story included images or other content to aide in story telling and illustrating concepts.

Bonus Features: (up to 5% extra credit)

1. The author included elements, formats, or strategies that made the narrative particularly effective?

APPENDIX U. 2014 KEYWORD ICEBREAKER TEMPLATE

Name:______________________________

List three issues that are important to you:	List three places of interest to you:
1.	1.
2.	2.
3.	3.

List two herp taxa that interest you:

1.

2.

List three personal interests that you have:	List three career interests that you have:
1.	1.
2.	2.
3.	3.

APPENDIX V. 2014 PEER REVIEW, SELF-CRITIQUE, COVER LETTER INSTRUCTIONS

Peer review exercise

There are several reasons why peer review is a valuable exercise. First, peer review is a fundamental part of how professionals communicate. In the sciences and other disciplines, papers submitted are subject to peer review to determine whether the author has made a sufficient case that their research and interpretations are reasonable and merit publication. Second, addressing reviewer comments helps with revision, and many authors agree that papers are ultimately improved by addressing the comments of reviewers. **Third, serving as a peer-reviewer improves your own writing. That is, we improve our own writing through opportunities to contrast it against what others do and do not do well**.
The keys to being an effective peer reviewer are simple, (1) be a reader not an editor, (2) **be honest**, and (3) be constructive.

1. **Be a reader**: Many of you have received essays or assignments from professors marked with tons of tiny writing in the margin or drawing your attention to typos and grammar issues. This is editing. It draws the writer's attention to fixing minor details, and does little to force the writer to revise. Revision is not fixing typos and spelling. Revision is deconstructing, reorganizing and reconstructing points to make something more effective. Make it more concise, clearer, and more logical. When you read your peers' essays, do not dwell on minor issues like punctuation and grammar beyond noting whether there are sufficient grammatical problems to be distracting. Instead, read the essay for content and flow. Did they provide sufficient background, were their objectives clear, were points well organized and supported by logical argument and evidence, was information accurate, did they address all the required elements, and finally, did the provide a conclusion that restated their key points.
2. **Be honest**: You do not help your colleague by blowing sunshine up their #!&*!. Don't take criticism of your writing personally, and be willing to give and except honest critiques. If an essay is awful, tell the writer it was awful. If you struggle with it, tell them you struggled with it. An author cannot know how much revision an essay needs if they do not honestly know how effective their essay is.
1. **Be constructive:** Though it can at times be difficult, try and find both positive and negative things in your peers' essay. Criticism is inherently negative, so to be constructive it must be honest and inspiring. Search for things the author did well that they can use to model improvements throughout their essay. For example, if the writing is disorganized, but they managed all or part of a good paragraph, point that out. You can also suggest things that you would do [or did] that might help, such as suggesting where an example would help, or pointing them to an idea.

What to do today:

For today's peer review, you will read the draft stories of two peers. Now, using the worksheets provided, address the following questions:

- Did the author succeed in setting the big picture context of the research? Did the author effectively describe the major theories or concepts that guided the research? How did they accomplish this or how could they be more effective?
- Did the author effectively organize the narrative? Did they draw the reader in early? Did they effectively develop the relevant characters? Did they provide essential background? How did they accomplish this or how could they be more effective?

- Did the author do an effective job at engaging you into the importance of this research? Did they effectively humanize scientists involved in the research? Did the author effectively portray the scientific process as a human endeavor?

After you read the essay, complete a peer review sheet. Then return the students essay and exchange review sheets, and discuss your reviews. **Remember to be honest and constructive.** After you have completed the peer-review, flip over the review sheet you received from your partner, and answer the remaining questions.

Essay critique and revision plan (due March 25, 2014):

Developing skills to critique and revise is a real challenge that even the more experienced writers struggle with their whole career. The objective of this assignment is to use your examination of peer essays to reflect on the strengths and weaknesses of your essay, and to develop a revision plan before you revise your essay. This assignment earns you 25 pts, and more importantly, should lead to more efficient and effective revision.

Elements of essay critique and revision plan:

8. In 1 paragraph, describe and defend what you did more effectively in your narrative compared to your peers' narratives.
9. In 1 paragraph, describe what was less effective about your narrative compared to your peers' narratives.
10. In 1 paragraph, describe two elements or approaches that you identified from your peers' narratives that you might incorporate into your own narrative.
11. List and prioritize the three most important and specific things you will do between now and your next draft to improve your narrative.
12. Identify one poorly constructed or grammatically incorrect sentence in your essay. Write the sentence as it appears in the essay you submitted. Then, rewrite the sentence to be grammatically correct and more effective.
13. Identify and describe 1 typo or mistake from your essay.

Cover letter for revised essay (due with revised draft):

Effective revision is seldom [if ever] achieved in single effort. Effective revision requires focusing on a few key changes, and then reassessing the essay after those changes. Effective revision requires draft, review, reflect, plan, and revise, and we repeat that process until the product is finished. So, it is unreasonable for you to achieve a finished project in a single revision. In your revision plan, you identified a few areas where you felt you could make substantive improvements. Your cover letter is intended to summarize the changes you may between this and the previous draft.

Cover letter elements:

1. In 1-2 paragraphs, summarize the 2 or 3 biggest weaknesses of your last draft and describe and defend how you addressed those weaknesses in this revision.
2. In 1 paragraph, summarize any additional substantive revisions you made to your prior draft.
3. In 1 paragraph, describe one outstanding weakness identified in your last draft by your peers or instructors that you still have not addressed in your revised essay.
4. In 1 paragraph, describe any writing strategies that you used to improve upon the quality of your second draft.

APPENDIX W. 2014 PEER REVIEW WORKSHEET

Did the author effectively explained a scientific project or issue as evidence by (1) adequately and accurately explaining the background information necessary for the target audience to understand the larger context including the theoretical or applied concepts, (2) accurately and thoroughly guiding the reader through how the actual work was conducted including details of approaches, and how data was collected and ultimately interpreted, and (3) clearly explaining the significance of the project's findings and how the project has advanced our scientific understanding?

Author name:______________________ Notes:	Author name:______________________ Notes:

Did The author effectively told a complete story as evidenced (1) following a story arc that made it recognizable as a story, (2) engaging the reader by explaining a problem, creating compelling drama or conflict, and providing resolution, and (3) consistently setting scenes, developing characters (people, animals, other things), and using other elements of good story telling.

Author name:______________________ Notes:	Author name:______________________ Notes:

Was the overall quality of narrative good as evidenced by (1) the use of a clear and engaging writing style that was relatively free of typos and grammatical errors; (2) effectively organizing the story as information, and (3) using elements, formats, or strategies that made the narrative particularly effective?

Author name:______________________ Notes:	Author name:______________________ Notes:

-complete reverse side of sheet-

Answer the following reflective questions in preparation for your final revisions:

1. What were the specific strengths of your essay. If possible, contrast your strengths with weaknesses identified in a peer's paper

2. What were the 2 or 3 biggest weaknesses of your essay? Be specific. Contrast your weaknesses with strengths identified in peer essays.

3. List some specific strategies that you can use to address the weaknesses in your essay for your next draft.