Measuring the Self-Directedness of Computer Science Learners

by

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Abstract

This study measured the degree of self-direction of students from the Department of Computer Science and Software Engineering at Auburn University. Self-direction was measured through the Personal Responsibility Orientation to Self-Direction in Learning Readiness Scale (PRO-SDLS), a quantitative instrument delivered via an electronic survey. 61 participants completed the survey, with a mean score of 85.88. In addition to measuring PRO-SDLS scores, this study also investigated if there differences in mean PRO-SDLS scores between gender, ethnicity, and age groups, as well as between sophomore, junior, senior and graduate students. No statistically significant difference was found between the groups. These results provide a better picture of self-direction among learners of computer science and software engineering, a field which has not yet been exhaustively researched.

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Chapter 1 - Introduction

Introduction

Computation has transformed the modern world to such an extent that it is difficult to find an area of society untouched by it. Work, education, research and entertainment have all been transformed by advancements in computation.

Due to the tremendous importance of computation, Computer Science has emerged as an important field of study and as a desirable career path. These factors attract thousands of prospective students of Computer Science every year. In doctoral-granting institutions in the United States and Canada, enrollment in Computer Science undergraduate majors more than tripled from 2006 to 2011 and more than doubled from 2011 to 2016 (Computing Research Association, 2017). Good financial prospects might partially account for this boom. A 2017 survey from the National Association of Colleges and Employers (NACE) found that Computer Science majors had the highest average starting salaries of all surveyed categories, which included engineering, business, social sciences, and humanities majors, among others. Earnings have been demonstrated to be a significant motivator for undergraduate major choice (Baker, 2018; Ko & Jun, 2015; Montmarquette, Cannings & Mahseredjian 2002). All these points make Computer Science learners an important population for further study.

There exists plenty of anecdotal evidence about how often students of computer science learn on their own. Scholarly articles about this subject usually acknowledge this in their introductions (Boyer, Langevin & Gaspar, 2008; McCartney, Boustedt, Eckerdal, Sanders, Thomas & Zander, 2016). Non-scholarly sources provide additional support to this assumption. In its 2019 yearly survey, Stack Overflow, a popular website for questions and answers about programming, had 85.5% of over 84.000 respondents say that they had taught themselves a new programming language, framework, or tool without taking a formal course. In the same survey, over 62% of respondents majored in Computer Science. These results indicate that Computer Science learners pursue self-direction in learning even when enrolled in a formal educational setting.

Statement of Problem

Although non scholarly sources provide ample evidence that computer science learners learn on their own, scholarly literature on the subject remains sparse. This is especially noteworthy considering three factors. First, that the phenomenon of self-direction in learning in computer science is so common that, as Zander et al. (2012) states, it becomes something that students are expected to do in addition to learning from their classes. Second, that, in the adult education literature, self-directed learning of other topics in adulthood is well-researched. Third, the high enrollment trends in computer science over the last decade indicate that this is an issue that affects a large population. As such, it is important to understand how these learners engage in self-directed learning so that faculty and administrators can provide them with the adequate support and resources that they need.

Purpose of Study

The purpose of this study was to examine the self-directed learning readiness of Auburn University's Department of Computer Science and Software Engineering (CSSE) undergraduate and graduate students, measured through the Personal Responsibility Orientation to Self-Direction in Learnin Scale (PRO-SDLS) (Stockdale & Brockett, 2011).

Five research questions guide the present study:

1. How do Auburn University's CSSE students score in the PRO-SDLS?

2. Are there statistically significant differences in PRO-SDLS score by gender?

3. Are there statistically significant differences in PRO-SDLS score by ethnicity?

4. Are there statistically significant differences in PRO-SDLS score by age?

5. Are there statistically significant differences in the PRO-SDLS score among freshman, sophomore, junior, senior, and graduate CSSE students?

Limits of Study

This study is based upon the analysis of a survey. One of the limitations is that the researcher assumes participants are honest in the responses they provide, since it is impossible to verify the truthfulness of every response. Another limitation is that the participants of this study were undergraduate and graduate students of Auburn University, so the results might not apply to other populations in other universities or countries. The researcher does not have a background in computer science other than brief enrollment in a computer science undergraduate major, and so might be subject to bias or lack of awareness of the complexities of that subject matter.

Definition of Terms

Self-Direction in Learning – In this study, we use the definition of self-direction in learning as defined by Brockett and Hiemstra's (1991) Personal Responsibility Orientation (PRO) model. The PRO model views self-direction in learning as a result of two different phenomena: self-directed learning and learner self-direction. Self-directed learning relates to the characteristics of the teaching-learning transaction, whereas learner self-direction is a personal characteristic of the learner. According to the PRO model, self-direction in learning is the concept that had been defined by Knowles (1975) as "a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes." (p. 18) Since

Knowles’ definition accounts for learning that occurs “with or without the help of others”, we can apply that definition to computer science learners who devise their own projects or methods of study to practice subjects that they have learned in class. Chapter 2 will discuss the PRO model in greater detail.

Computer Science – We used Computer Science, in its broadest sense, to describe the systematic study of computers. This includes the study of software engineering, programming, data structures, networking and theoretical computation. However, for the purposes of this study, Computer Science will generally refer to a Computer Science program in the context of a university major or course of study.

Organization of Study

This study will be divided into five chapters. Chapter 1 contains the introduction, statement of problem, purpose and limits of study, as well as a definition of significant terms. Chapter 2 presents a review of the literature on self-directed learning, motivation, and educational research of computer science learners. Chapter 3 will detail the methods used in this study. Chapter 4 will present the results of this study. Lastly, Chapter 5 will present a summary and conclusions for this study, as well as recommendations for further research in this topic.

Chapter 2 – Literature Review

Self-Direction in Learning Within Adult Education

Self-directed learning among adults is a concept perhaps as old as civilization itself. For Kulich (1970), before the "fairly recent wide-spread and readily available schooling for everybody, self-education was the prime way for man to cope with the world around him" (p. 1). For instance, he found evidence of self-directed learning among ancient Greek philosophers. Kulich notes that Socrates and Plato spoke about self-education as an ideal quality and as a virtue of the wise, whereas Aristotle regarded it as a potentiality that exists in all individuals and could be developed by themselves or by a teacher. From these early philosophers, Kulich traced a history of self-directed learning that encompasses much of Western history, drawing examples from instructional manuals in the 1500s to correspondence courses in the United States during the 1960's.

Even though self-learning is an ancient concept, scholarship on the subject is comparatively recent (Candy, 1991). Multiple sources (Candy, 1991; Merriam & Caffarella, 2007; Brookfield, 1985; Hiemstra, 1994; Brockett & Donaghy, 2005) point to two pioneering studies as the earliest and most influential in the field of self-directed learning in adulthood.

The first of them is *The Inquiring Mind*, a 1961 study by Cyril O. Houle. Houle's study, formatted as a "brief, lucid, scholarly essay" (Candy, 1991, p. 25), interviewed 22 adults of diverse backgrounds who were "conspicuously engaged in various forms of continuing learning" (Houle, 1961, p. 13) to such an "outstanding degree that they could be readily identified for me by their friends or by the counselors and directors of adult educational institutions" (p. 4). About these adults, Houle wanted to ask "the usual questions—who, what, when, where, and why—and examine such other more complicated matters as may seem appropriate (p. 4).

Houle's mention of "the usual questions" reflects his preoccupation of distinguishing this investigation from other works in adult education at the time. These studies focused on participation in established educational institutions, such as universities, libraries, evening schools, and community centers. In contrast, the starting point for Houle's study was "not the act of participation, but the participant" (p. 9). This, he argued, would lead to a deeper understanding of the reasons and processes adults use when engaging in continuing education, as well as encompass a broader population than the well-educated, high-income adults that typically frequented more established educational institutions.

Houle found that, among his participants, there were three different types of continuing learners. First, there were *goal-oriented* learners, for whom education was usually a means of attaining a particular goal, such as a certificate or promotion. Second, there were *activity-oriented* learners, who participated in learning activities for various reasons, including to stave off loneliness, to find a spouse, and to comply to family or cultural traditions. These learners primarily sought social contact, and as such, placed more importance on the act of learning itself, rather than the content. But it was the third group, which differed markedly from the other two, that was most interesting for the field of self-directed learning (Brockett & Donaghy, 2005). These were the *learning-oriented* learners, who were moved chiefly by an intrinsic "desire to know" (Houle, 1961, p. 25). For them, learning was an innately enjoyable experience and a constant throughout most of their lives.

Houle intended his study as a primer on the subject of "outstanding" continuing learners, rather than a thorough description, and called for "later and fuller development" (p. 4) on the study of such learners. And, indeed, a few years later, one of his doctoral students would focus his attention on learning-oriented individuals (Hiemstra, 1994).

This student was Allen Tough, a Canadian educator whose 1971 study *The Adult's Learning Projects* is the second influential work on self-direction most consistently identified in the literature. Tough attributed his interest in self-directed learning to a graduate course he took in 1963, taught by Houle (Tough, 1967). Tough did his doctoral dissertation on that subject, which he published in a condensed form in 1967. Four years later he published *The Adult's Learning Projects,* which built upon data from his dissertation and subsequent studies on the subject.

Tough, who was inspired by Houle to direct his efforts to individuals rather than institutions (Tough, 1971, p. 2), focused his study on the "highly deliberate" efforts adults undertake to gain knowledge, skills, or in other ways effect change in themselves. Tough calls these efforts *learning projects*, which he defines as

> a series of related episodes, adding up to at least seven hours. In each episode, more than half of the person's total motivation is to gain and retain fairly clear knowledge or skill, or to produce some other lasting change in himself. (p. 7)

This definition, with its careful attention to the motivation, content, and duration of learning, is meant to "separate major learning efforts from those that are not very significant or intensive" (p. 15).

In *The Adult's Learning Projects*, Tough provides a general description of learning efforts in adulthood. He found that adults undertook a median of 8 major learning projects per year, and almost 90% of adults undertook at least one learning project a year. In most cases, these learning projects were motivated by "some fairly immediate problem, task, or decision that demands certain knowledge and skill" (p. 40), and rarely were adults interested in learning the entire body of knowledge of a field.

Because Tough's intentions were to encompass all adult learning, the learning projects he described include participation in common educational settings (such as a classroom), where someone else plans and often facilitates learning. However, in 68% of cases, the adult themselves planned their learning projects. By "planning" a learning project, Tough referred to the decision regarding the content, method, schedule and pace of learning episodes. Once planned, the adult may rely on different sources to deliver the learning content, which might include human resources (such as a teacher) or non-human resources (such as a book). Tough identified 13 "clusters" of steps that adults took when planning a learning project. These steps (which appear here condensed, for conciseness) include:

- Deciding what knowledge and skill to learn
- Deciding the specific activities, methods, resources or equipment for learning
- Deciding where to learn and setting up that space accordingly
- Scheduling the learning project, which includes setting deadlines, deciding when to begin, and determining the pace of learning
- Estimating current level of knowledge and skill
- Obtaining the resources necessary for the learning project, including saving or obtaining money for acquiring these resources
- Finding ways to increase motivation (Tough, 1971, pp. 95-97)

For Brockett and Donaghy (2005), Tough's study of self-planned learning reflects a conceptual maturation within the field self-directed learning. The term "self-planning" itself indicates that: instead of "self-teaching", a term common in the early research on self-direction which carries connotations of learning strictly from oneself, with no outside help, the term "self-planning" suggests the reliance on other resources as an integral aspect of self-directed learning (Kasworm, 1992).

The seminal works of Houle and Tough were followed in the 70's by others that further defined and popularized self-directed learning. Most important among those is Knowles' *Self-Directed Learning* (1975), which provided one of the earliest comprehensive definitions of self-directed learning: "a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" (p. 18). Knowles recognized the importance of earlier labels, such as self-planned learning and self-teaching, but found that they did not convey the social nature of self-direction and its reliance on various external helpers.

Knowles posited that his definition of self-directed learning was inextricably linked to *andragogy*, a concept he devised to describe the unique characteristics of the adult learner in an earlier work, *The Ault Learner* (1973). For Knowles, andragogy was a set of four assumptions about the adult learner:

1. Self-Concept: As adults mature, their self-concept moves from being dependent toward being self-directed.
2. Adult Learner Experience: As adults mature, they accumulate experience, which becomes an increasing resource for learning.
3. Readiness to Learn: As adults mature, their readiness to learn becomes increasingly oriented to the developmental tasks of their social roles.
4. Orientation to Learning: As adults mature, their perspective changes from one of postponed application of knowledge to immediacy of application. As a result,

their orientation toward learning shifts from subject-centeredness to problem centeredness. (Knowles, 1973)

In a later edition of *The Adult Learner,* Knowles added a fifth assumption:

5. Motivation to learn: As adults mature, their motivation to learn becomes intrinsic, rather than extrinsic (Knowles, 1984).

Another important work in the mid to late 1970's was Guglielmino's self-directed learning readiness scale (SDLRS). One of the first quantitative instruments to measure self-directed learning, the SDLRS is comprised of 58 Likert-scale items that measure the degree to which an adult is ready to engage in self-directed learning. Guglielmino performed a factor analysis on the 58 items and found that the items represented eight factors: love of learning; self-concept as an effective independent learner; tolerance of risk, ambiguity, and complexity in learning; creativity; view of learning as a lifelong, beneficial process; initiative in learning; self-understanding; acceptance of responsibility for one's own learning (Guglielmino, 1977).

Although the SDLRS has been used extensively, researchers have raised significant concerns about the instrument. Most notably, Field (1989) argued that the instrument was conceptually and methodologically flawed to such an extent that its use should be discontinued. Additionally, the construct validity, applicability of the instrument to diverse populations, accuracy of the eight factors, and availability of the survey have been intensely debated (Fisher, King, & Tague, 2001). Nevertheless, the SDLRS remains the instrument most widely used to measure self-direction (Merriam, Caffarella & Baumgartner, 2007).

By the start of the 1980s, self-directed learning was widely studied and regarded as a core aspect of adult education. Throughout that decade, almost every book published in English on adult learning discussed self-directed learning in one way or another (Candy, 1991). That surge in interest stemmed partly from the perception that self-direction was a hallmark of the adult learner (Mezirow, 1985) and "the long-term goal of most, if not all, educational endeavors (Candy, 1991). In fact, Knowles considered self-direction as one of the distinguishing characteristics of the adult learner as early as 1973, when he outlined the concept of andragogy in *The Adult Learner*.

The importance of self-directed learning as a research topic and the sheer number of studies focused on that subject led to increased scrutiny. For instance, in a critical review of the literature on self-directed learning, Brookfield (1985) argued that studies often displayed a lack of variety both in their methods, "quasi-quantitative" instruments that closely resembled those used by Tough and his associates in early studies, and in the populations they targeted—usually middle-class and well-educated (p. 12). He was concerned that self-directed learning was becoming an "orthodoxy" (p. 5) and an idea often accepted uncritically in the study of adult education. Brookfield was also skeptical of the idea of self-directed learning as solely the "command of self-instructional techniques". This, he argued, placed too much importance on the instructional methods and not enough on the potential of individuals for critical reflection. In this manner it was "possible to be a superb technician of self-directed learning … and yet never ask whether one's intellectual pursuit is valid or worthwhile" (p. 15). Brookfield advocated that future studies made a distinction between self-direction as an instructional technique and self-direction as an internal shift in consciousness.

Brockett and Hiemstra (1991), despite characterizing Brookfield's view as unnecessarily pessimistic, nevertheless shared the same concerns about the conceptual misunderstandings regarding self-directed learning. They argued that the breadth in research on the field led to confusion about what self-directed learning meant as a construct. Different studies defined "self-directed learning" in different ways, and in some cases, applied that same label to different constructs. After presenting a review of past attempts at identifying the different constructs that fell under the umbrella of "self-directed learning", including Kasworm (1983), Fellenz (1985), Oddi (1987), and Candy (1991), Brockett and Hiemstra arrived at their own *Personal Responsibility Orientation* (PRO) model of self-direction in learning.

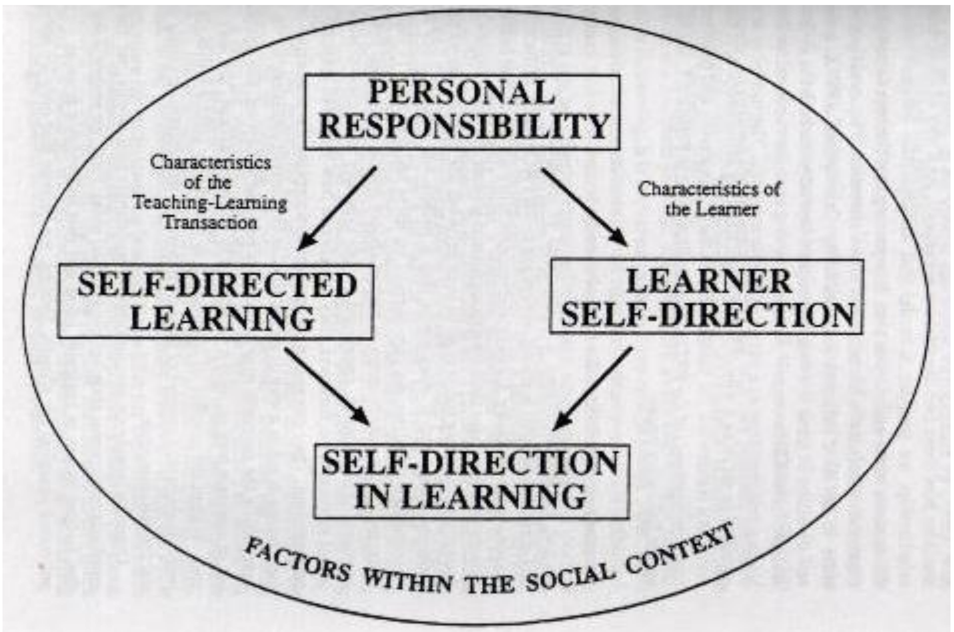


Figure 2.1. The PRO Model

The central distinction the PRO model makes is between *self-directed learning*, an instructional method, and *learner self-direction*, a characteristic of the learner. For Brockett and Hiemstra, self-directed learning is "a process that centers on the activities of planning, implementing, and evaluating learning" (p. 28). This is the exact same process that was described in earlier scholarship, including Tough's (1971) research and Knowles' (1975) definition. Learner self-direction, on the other hand, refers to "characteristics of an individual that predispose one toward taking primary responsibility for personal learning endeavors" (p. 29). Both these dimensions are anchored in the idea of *personal responsibility,* which means an assumption of ownership for one's thoughts and actions (p. 27). Both the external, process-oriented concept of self-directed learning and the internal, personal-oriented learner self-direction describe the larger phenomenon of *self-direction in learning,* which, as Brockett and Hiemstra note, always happens within a social context. Figure 2.1, above, illustrates this definition.

The Personal Responsibility Orientation to Self-Direction in Learning (PRO-SDLS) is a survey that was developed to measure self-directedness of college students (Stockdale & Brockett, 2011). It is based upon an operational definition of the PRO model and consists of 25 Likert-scale items across four latent variables. The PRO-SDLS was developed in part as an alternative to Guglielmino's (1977) SDLRS. Stockdale and Brockett, while acknowledging the contribution of SDLRS for the field, note the many criticisms on the instrument which have been described earlier in this chapter. As it is the primary instrument used in this study, PRO-SDLS, its four latent variables, and the operational definitions it uses will be described in more detail in the methods section of this text.

By the mid-1990s, self-direction in learning was a mature area of research within adult education. Enough time had passed since the publication of its foundational works to allow for critical perspectives such as Brookfield's (1985), and the discussions they prompted (Brockett, 1985) led to broader and more nuanced outlook on self-direction. Around that time, personal computers and the internet were becoming more and more accessible for a larger portion of the population. This brought exciting new possibilities and radical change for self-directed learning (Fischer & Schaff, 1998; French, 1999). As such, the interplay between self-directed learning and technology has been a significant focus of research for the past 20 years.

The following studies provide an indication of the breadth of research on self-direction and technology. Hiemstra (2006) has studied the experience of internet learners who lived in rural areas. Bonk, Lee, Kou, Xu and Sheu (2015) studied the learning goals, preferences, and challenges of learners using the Massachusetts Institute of Technology's (MIT) OpenCourseWare – an initiative which publishes all course content from MIT in the internet, for free. Lai (2015) examined how to teach the use of technology for self-directed learning. Lastly, Rashid and Asghar (2016) found that students who used technology extensively tended to be more self-directed.

Computer Science and Self-Direction

According to Boyer, Langevin, and Gaspar (2008), "computing professionals are required to leverage self-direction in their lifelong learning in order to constantly adapt to new emerging technologies" (p. 1). This is such an oft-repeated notion that Zander, Boustedt, Eckerdal, McCartney, Sanders, Moström, and Thomas call it an "accepted wisdom" (2012, p. 111) within the field. While it is true that the need to learn in order to stay current applies, to some degree, to all professionals, this is especially true of computing professionals due to the nature of their work (Zander et al., 2012). Technology brings about rapid and sometimes fundamental change, which means computing professionals have a particularly strong need for self-direction.

The work of Zander et al. (2012) shows how prevalent and important self-direction is for computing professionals. In an interview with ten computing professionals, self-direction was mentioned as an essential skill in the workplace. According to these professionals, self-direction is implicitly expected of new hires and is also key for continued success in the field. Most of the interviewees regarded themselves as competent self-directed learners and were proud of their learning endeavors. However, they also expressed negative feelings toward self-directed learning. In some cases, the motivation for a self-directed learning experience stemmed from immense pressure to complete a project, or from a sense of intimidation that they did not know as much as their peers. The constant need for self-direction could also lead to burnout or insecurities about staying relevant as a professional.

Despite being fundamentally important for computing professionals, self-direction is not often taught to college students of computer science, and fundamental skills in the discipline, such as programming, are usually taught through lectures and other teacher-centered instructional methods (Tirronen & Isomöttönen, 2012; Noor, Harun, & Aris, 2014). This is due, in part, to the complexity of the subjects. Programming, for instance, is considered hard to learn (Noor et al, 2014), especially for students with no prior experience. Ponti (2013) shows that beginner programmers can struggle with self-direction and might express a desire for guidance.

In summary, self-direction is an essential skill for computer science professionals, but it is not widely used as an instructional method in formal educational settings. Research on the intersection between computer science and self-direction reflects this lack of widespread use, as there is not a comprehensive or influential theoretical work in that research area, and, for the most part, the articles do not reference each other. Research on computer science and self-direction can be categorized according to four approaches:

1. Research on the impact of self-directed learning methods on student learning and performance.
2. Development of instructional methods that foster self-direction.
3. Research on problem-based learning and its influence on self-direction in learning.

4. Studies that attempt to measure learner self-direction directly or as consequence of a related characteristic (such as preference of andragogical teaching methods).

These four approaches will each be analyzed below. But before that, it is important to define and distinguish self-direction from a related concept.

Self-Regulated Learning

This literature review identified a rich body of literature on self-regulated learning within programming and computer science (Bergin, Reilly, & Traynor, 2005; Lenne, Abel, Trigano, & Leblanc, 2008; Çakıroğlu & Öztürk, 2017; Garcia, Falkner & Vivian, 2018).

Self-regulated learning is a theory of learning rooted in cognitive psychology that seeks to analyze how learners independently regulate their cognition, motivation, and behavior during the learning process (Saks & Leijen, 2014). This definition bears similarities to self-directed learning theory, and, indeed, scholars have found significant links between the two theories (Pilling-Cormick & Garrison, 2007). However, there are also significant differences. Jossberger, Brand-Gruwel, Boshuizen and Wiel (2010) argue that self-regulated learning describes learning at the micro-level, with particular attention given to the metacognitive processes that learners employ. Self-directed learning, on the other hand, views learning on a macro-scale, and for that reason it accounts for phenomena (such as the planning of the learning process) that fall outside the scope of self-regulated learning. To Jossberger et al., self-regulated learning is contained within self-directed learning. In this way, it would be possible for a learner to be self-regulated, but not self-directed.

The studies on self-regulated learning within computer science that we identified reflect Jossberger et al.'s distinction. These studies tend to deal with the strategies employed by students in order to make sense of homework and content they learned in class. This is also in line with

Saks and Leijen's (2014) review, which identified that studies on self-regulated learning tended to prioritize learning that occurred in a school environment, with tasks usually determined by a teacher. By contrast, self-directed learning usually encompasses learning practiced outside a traditional school environment.

Although the population for this study is comprised of students in a formal educational setting, this study is interested in their potential for broader self-direction, rather than the metacognitive processes that are tied more directly to what they learn from their professors. For this reason, we will not focus on self-regulated learning in this review of the literature.

Impact of Self-Directed Learning Methods On Student Learning

Ellis (2007) surveyed student reactions to a self-directed approach to a Web-application design and development course. The course supported self-direction in two ways. First, it featured a student-defined team project. In this project, students were tasked to develop a web-application directed at any topic of their choosing; past examples included on-line weather prediction and terrorism response planning sites that supported self-direction. This project accounted for 60% of their final grade. Second, students used a self-grading scheme to assess their web-application; the professor could make small alterations to the final grade. Students were surveyed about their satisfaction twice: at the fourth week and at the end of the semester. The results indicated "a high degree of student satisfaction with both the self-determined approach and the course overall" (p. 60). Additionally, 91% of students achieved a grade of A or B on the course, indicating that they had mastered the content of the course. The instructor also noted that the student-determined projects were more complex compared to past offerings of the course, when all students implemented the same, teacher-determined application.

Brannan, Marley, Fallon, & Bower (2014) incorporated a self-directed learning module to a computer applications course offered to civil engineering sophomore students. In the module, students received an assignment. In order to complete that assignment, students would need to learn a programming concept that had not been introduced or discussed previously during the class. The module also taught students about lifelong and self-directed learning. At the end of the semester, students were surveyed about their experiences. Students indicated a high degree of satisfaction with the module and indicated that it helped develop their self-directed learning skills.

Teaching Methods

A number of studies focus on the development of teaching methods that foster self-direction, either for engineering students in general (Böhne, Faltin, & Wagner, 2002; Fellows, Culver, Ruggieri & Beston, 2002; Miller, DeClerck, Endres, Roberts, Hale, & Sorby, 2013) or for the teaching of computer programming specifically (Tirronen & Isomöttönen, 2012; Dichev & Dicheva, 2013).

Problem-Based Learning

Another area of focus is *problem-based learning* (PBL), which has been shown to contribute to self-direction for learners of computer science (LeJeune, 2002; García-Famoso 2005; Havenga, 2015). PBL can be defined as "learning by solving a large, real-world problem" (Barg, Fekete, Greening, Hollands, Kay, Kingston & Crawford, 2000, p. 111). PBL goes beyond simply using problems to illustrate or further explain concepts. Instead, it places problem-solving at the center of the learning experience (Barg et al., 2000). While it has originated in medical science, PBL has been used in other disciplines such as education and engineering (LeJeune, 2002).

PBL involves approaching a problem with no previous preparation. It requires learners to analyze the problem, determine and locate resources to use, justify a potential solution, and, in general, take responsibility for their own learning. (García-Formoso, 2005). These steps show clear links to self-direction in learning, and in fact closely resemble those outlined by Tough (1971) in his description of the self-directed learning process.

Measuring Self-Direction

Several studies have measured self-direction among learners of computer programming. Three of these studies (Chou, 2012; Noor et al., 2014; Álvarez, Fajardo, Meza, & Vásquez, 2019) targeted non- learners of computer programming who were not computer science majors. Another study (Boyer et al., 2008) targeted computer science majors and surveyed students using the PRO-SDLS. This study closely resembles the present research, and for that reason its results will be described in greater detail.

Chou (2012) examined the correlation between SDLRS scores and learning outcomes in a programming course taught online. The participants were 38 students of electrical engineering in a Taiwanese university. The study found no significant differences in learning outcomes based on SDLRS scores. The mean SDLRS score was 205.5, which is considered average for adults according to Guglielmino (1977).

Noor et al. used an independently developed instrument, based on Delahaye, Limerick, and Hearn's (1994) four stages of learning, to determine learning preferences among learners of programming who were not computer science majors. The participants were 262 students enrolled in an introduction to programming course at a Malaysian university. The research found that learners displayed high learning orientations for both pedagogy and andragogy. The researchers concluded that, although these learners displayed enough self-direction to work independently, they were still not prepared to take full responsibility for their learning and required guidance from their professors.

Álvarez et al. (2019) surveyed 1694 students taking an introductory programming course at a Chilean university. These students were enrolled in a variety of STEM majors, including informatics, civil engineering, and mechanical engineering. The survey included a modified version of the SDLRS, which the authors further subdivided into five constructs: planning, wish to learn, self-confidence, self-management, and self-evaluation. Out of all majors, informatics majors displayed the highest wish to learn scores. The remaining four constructs saw comparatively small differences across STEM fields. Researchers also compared differences between male and female participants and found that males scored higher in the wish to learn construct than females.

Boyer et al. (2008) surveyed 15 computer science learners at a four-year institution in the state of Florida. Of the 15 participants, 8 were enrolled in an introductory and 7 in an intermediate computer programming course. According to the researchers, most participants were non-traditional students who had transferred from two-year institutions, and who attended classes at night and worked during the day.

These participants were surveyed using the PRO-SDLS. The 8 students in the introductory course received an additional open-ended question, which asked them to provide complementary feedback on how the course influenced their self-direction. Participants took an average of 15 minutes to complete the survey.

Table 2.1

PRO-SDLS Results

	Mean	St. Deviation	Minimum	Maximum
Introductory Course (N=8)	93.75	13.38	72.00	112.00
Intermediate Course (N=7)	85.00	8.93	71.00	95.00
Combined Courses	89.67	12.00	71.00	112.00

The study found that all students scored in the moderate to high range for all four factors in the PRO-SDLS. Students in the introductory course scored higher means than students on the intermediate course. On average, students in the introductory course scored higher than students in the intermediate course for all factors except motivation.

Table 2.2

Factor PRO-SDLS Scores

	Teaching Learning Transaction Component		**Learner Characteristics Component**	
	Initiative – 6 Questions	**Control – 6 Questions**	**Self-efficacy – 6 Questions**	**Motivation – 7 Questions**
	High – 24-30 Moderate – 15-23 Low – 6-14	High – 24-30 Moderate – 15-23 Low – 6-14	High – 24-30 Moderate – 15-23 Low – 6-14	High – 28-35 Moderate – 16-27 Low – 7-15
Introductory Course (N = 8)	24.13 – High	22.00 – Moderate	24.25 – High	20.63 – Moderate
Intermediate Course (N = 7)	19.29 – Moderate	20.00 – Moderate	21.14 – Moderate	21.14 – Moderate

Conclusion

This literature review has provided a historical perspective of the study of self-direction in learning within adult education. It identified the seminal works of Houle (1963) and Tough (1971), the evolution of definitions for self-direction in learning, critical perspectives of self-direction in learning, the development of the PRO model, and the PRO-SDLS, a quantitative instrument based on the PRO.

This review then provided an overview of the literature on self-direction for computer science learners. Specifically, it identified several studies, but found no central, influential works upon which these studies were based. It categorized the research on self-direction in learning in four approaches: the impact of self-directed learning methods on student learning and performance, development of instructional methods that foster self-direction, problem-based learning, and measures of learner self-direction.

Chapter 3 – Methods

Research Design

This study sought to determine the degree of self-direction in learning of students from the Department of Computer Science and Software Engineering (CSSE) at Auburn University, as measured by the Personal Responsibility Orientation to Self-Direction in Learning Scale (PRO-SDLS) (Stockdale & Brockett, 2011). This study was designed to answer the following questions:

1. How do Auburn University's CSSE students score in the PRO-SDLS?
2. Are there statistically significant differences in PRO-SDLS score by gender?
3. Are there statistically significant differences in PRO-SDLS score by ethnicity?
4. Are there statistically significant differences in PRO-SDLS score by age?
5. Are there statistically significant differences in the PRO-SDLS score among freshman, sophomore, junior, senior, and graduate CSSE students?

To answer the research questions, this study adopted a correlational research design.

Instrument

The instrument used in this study was Stockdale's (2011) PRO-SDLS. The PRO-SDLS is based on an operationalization of Brockett and Hiemstra's (1991) Personal Responsibility Orientation (PRO) model, which has been described earlier in the literature review.

The PRO model defines self-direction in learning as a phenomenon comprised by two components: self-directed learning (as an instructional process) and learner self-direction (as a characteristic of the learner). Likewise, the PRO-SDLS has two components. For each component, there are two factors, which were established after a confirmatory factor analysis, and relate to operationalized definitions of aspects of the PRO model. The first component is the *teaching-learning transaction* (TLT), which represents self-directed learning. This component is concerned with "actions that demonstrate proactively assuming control and initiative for planning, implementing, and evaluating the learning process" (p. 165). As this definition indicates, the TLT component is made up of two factors: initiative and control. The second component is *learner characteristic* (LC), which is concerned with the autonomous motivation, self-confidence, and self-regulating behaviors. As such, the LC component is divided into two factors: motivation and self-efficacy.

The PRO-SDLS consists of 25 Likert-scale items. Respondents indicate their level of agreement with each item, ranging from 'strongly disagree' (value of 1) to 'strongly agree' (value of 5). Some items in the PRO-SDLS are reverse scored, to avoid the influence of respondents' potential tendencies to say "yes" (Stockdale & Brockett, 2011). The maximum possible score on the PRO-SDLS is 125, with higher scores indicating higher self-direction. The factors initiative, control, and self-efficacy represent six questions each; the maximum possible score for these factors is 30. The other factor, motivation, represents seven questions, with a maximum possible score of 35. Permission to use the PRO-SDLS in this study was sought from Dr. Stockdale. Her approval is indicated in appendix A.

The PRO-SDLS was used in this study for several reasons. First, it is based on the PRO model, which allows for an understanding of self-direction in learning both as an instructional process and as a learner characteristic. Second, the relatively small number of items (25) as it could aid survey response and completion rates. Third, the survey's Cronbach alpha was measured by Stockdale and Brockett (2011) as $\alpha = .95$, indicating a high degree of internal consistency. And finally, after receiving permission from Dr. Stockdale, the instrument was available for use at no cost.

Data Collection

Data collection happened through an electronic survey developed through Qualtrics, a survey tool that is available to Auburn University students. The survey contained demographic questions to determine participants' age, gender, ethnicity, and educational status (freshman, sophomore, junior and senior), as well as the 25 items of the PRO-SDLS. A After receiving IRB approval, the researcher contacted Dr. Hari Narayanan, chair of the department of CSSE at Auburn University, who granted permission to survey students enrolled at the department. To recruit participants, the researcher sent emails to the staff of the department of CSSE, who then forwarded the emails to all students who were majoring in a graduate or undergraduate program at the department of CSSE. At no point in the process the researcher had access to emails or any other identifiable information from participants in this study. In addition, the survey also did not collect IP addresses from respondents. A recruiting email, which contained the link to the Qualtrics survey and an IRB-approved information letter (indicated in appendix C), was sent on January 13, 2020. Two reminder emails were sent on January 21 and January 26. The survey was closed on January 31, three weeks after the recruitment email had been sent.

Population and Sample

The participants of this study are Auburn University students who were majors in one of the programs of the department of CSSE at Auburn University. A total of 61 participants completed the survey, out of 83 partial completions, indicating a completion rate of 73.4%. Participants took an average of 7 minutes and 89 seconds to complete the survey. The sample's mean age was 23.2 years, with the youngest respondents being 19 to and the oldest respondent

35 years of age. The median age was 22 years. Participant's ages were categorized into three age groups, described in the table below, to aid analysis.

Table 3.1

Demographic Data

	N	**Percent**
Gender		
Male	44	72.1%
Female	17	27.9%
Ethnicity		
African-American	4	6.6%
Asian	12	19.7%
Caucasian	37	36.4%
Hispanic	4	6.6%
Other	4	6.6%
Age		
19-23	38	62.2%
24-29	18	29.5%
30-35	5	8.1%
Academic Status		
Freshman		
Sophomore	9	14.8%
Junior	15	24.6%
Senior	23	37.7%
Graduate	14	23.0%

Variables

The independent variables for this study are gender (male and female), ethnicity (Caucasian and Non-Caucasian), age group (19-21, 22-25, and 26-35), and current academic status (freshman, sophomore, junior, senior, or graduate). The dependent variable in this study is the PRO-SDLS score.

Data Analysis

Data was analyzed using SPSS, a statistical analysis software that is available to Auburn University students. Qualtrics was also used for descriptive statistics. The quantitative methods used for each research questions were as follows:

- Research question 1 was answered through descriptive data of PRO-SDLS scores.
- Research questions 2 and 3 were each answered through an independent means Student's t-test.
- Research question 4 was answered through a one-way Welch ANOVA
- Research question 5 was answered through a Kruskal-Wallis H test.

Chapter 4 – Findings

Research Question 1 - How do Auburn University's CSSE Students Score in the PRO-SDLS?

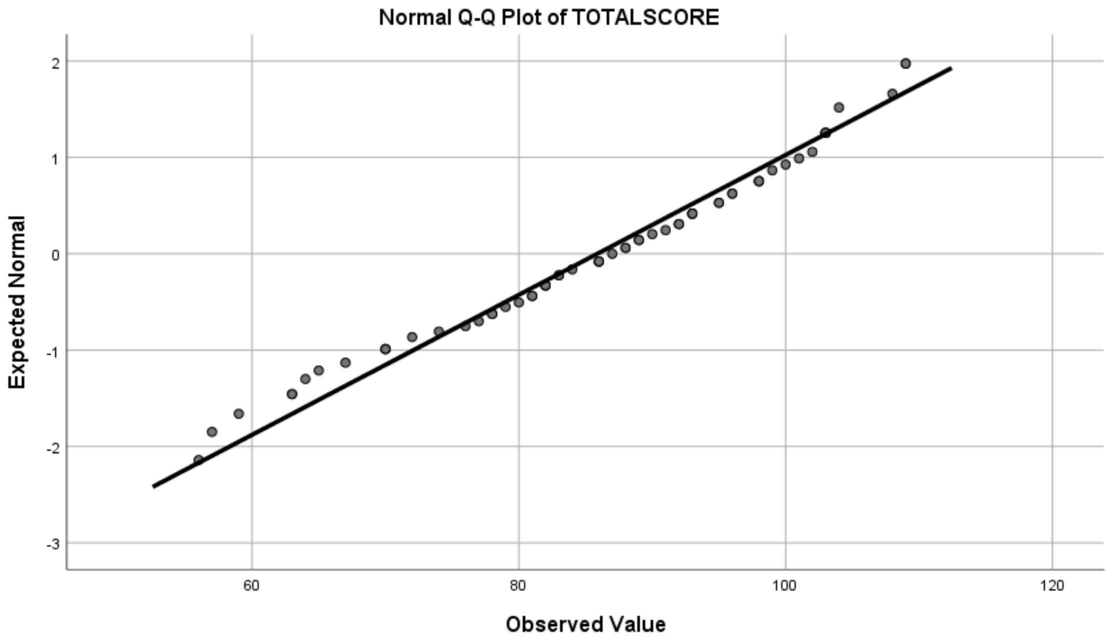
Table 4.1 - Descriptive Statistics for PRO-SDLS Scores

	N	Minimum	Maximum	Mean	Std. Deviation
Total Score	61	56.00	109.00	85.88	13.77
Initiative	61	7.00	28.00	20.54	4.48
Control	61	10.00	29.00	21.49	3.91
Self-Efficacy	61	6.00	30.00	22.60	4.60
Motivation	61	10.00	31.00	20.91	4.76

Overall, the 61 participants showed a mean PRO-SDLS score of 85.88. Minimum values, maximum values, and standard deviation all indicate great variability in scores. Overall, self-efficacy had the highest average scores of all four factors.

One participant showed a PRO-SDLS total score of 36.00. The value, while theoretically possible, was highly unusual and significantly below the minimum values reported in other studies that used the PRO-SDLS (Boyer et al., 2008; Hall, 2011; Carlisle, 2016). To aid data analysis, that value was winsorized to the next lowest value (56.00). After that procedure, a Q-Q plot generated from PRO-SDLS total scores (Figure 4.1) indicates that the data approximately fits a normal distribution.

Figure 4.1 – Total Score Q-Q Plot



The questions with the highest scores overall was “I often use materials I’ve found on my own to help me in a course” (4.16), followed by “I always effectively take responsibility for my own learning” (4.09) and “I am very convinced I have the ability to take personal control of my learning” (4.01). The questions with the lowest overall score was “the primary reason I complete course requirements is to obtain the grade that is expected of me” (2.00), followed by “the main reason I do the course activities is to avoid feeling guilty or getting a bad grade” (2.59), and “I complete most of my college activities because I WANT to, not because I HAVE to (2.86)”.

Research Question 2 - Are there statistically significant differences in PRO-SDLS score by gender?

Table 4.2

Descriptive Data for PRO-SDLS Scores by Gender

Gender	N	Mean	Min	Max	Std. Deviation
Male	44	87.00	63.00	109.00	12.56
Female	17	83.00	56.00	103.00	16.58
Total	61	85.88	56.00	109.00	13.77

Through inspection of a Q-Q Plot and the result of a Shapiro-Wilk test ($p > .05$), the distribution of scores of males and females was determined to be approximately normal. Furthermore, Lavene's test showed homogeneity of variances between the two groups ($p = .111$). These factors allowed for an independent means t-test to be performed. The null hypothesis for this research question was that there was no difference between mean PRO-SDLS scores between males and females. The results of the t-test show that the null hypothesis cannot be rejected. Therefore, despite males ($M = 87$) displaying higher mean PRO-SDLS scores that females ($M = 83$), this difference in means was not statistically significant

Table 4.3

t-test Results for PRO-SDLS Scores by Gender

t	df	p	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
1.017	59	0.313	4	3.93	-3.86	11.86

Research Question 3 - Are There Statistically Significant Differences in PRO-SDLS Score by Ethnicity?

The survey originally provided five different options for ethnicity: African American, Asian, Caucasian, Hispanic, and Other.

Table 4.4

Participant Ethnicities in Original Survey

Ethnicity	African American	Caucasian	Hispanic	Asian	Other
N	4	37	4	12	4

After data collection was finished, some of the options, such as Asian and Hispanic, represented only 4 respondents each. These group sizes meant that performing an ANOVA would not yield statistically robust findings. Since Caucasians made up the largest group (37 participants out of 61), the five groups were combined into two: Caucasians and non-Caucasians. Table 4.4 provides descriptive data for PRO-SDLS scores among the two groups.

Table 4.5

Descriptive Data for PRO-SDLS Scores by Ethnicity

Ethnicity	N	Mean	Minimum	Maximum	Std. Deviation
Non-Caucasian	24	83.79	56.00	109.00	15.60
Caucasian	37	87.24	63.00	109.00	12.48
Total	61	85.88	56.00	109.00	13.77

A t-test was employed to find if differences in means were statistically significant. The null hypothesis for this research question was that there was no statistically significant difference in mean PRO-SDLS scores between Caucasians and Non-Caucasians. Inspection of a Q-Q plot indicated that the scores were approximately normally distributed for both groups. A Shapiro-Wilk normality test corroborated the assumption of approximate normality ($p > .05$), and Levene's test provided support for the assumption of homogeneity of variances between the two groups ($p = .288$). The results of the t-test (Table 4.5) indicates weak evidence against the null hypothesis ($p = 0.343$). Based on data from descriptive statistics and the t-test, Caucasians showed higher mean scored from the PRO-SDLS than Non-Caucasians, but the difference is not statistically significant.

Table 4.6

t-test Result for PRO-SDLS Scores by Ethnicity

	t	df	p (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Total Score	0.95	59	0.343	3.45	3.61	-3.77	10.68

Research Question 4 - Are There Statistically Significant Differences in PRO-SDLS Scores by Age?

In the survey, participants reported their age via a text box. Figure 4.4 shows the distribution of participant ages.

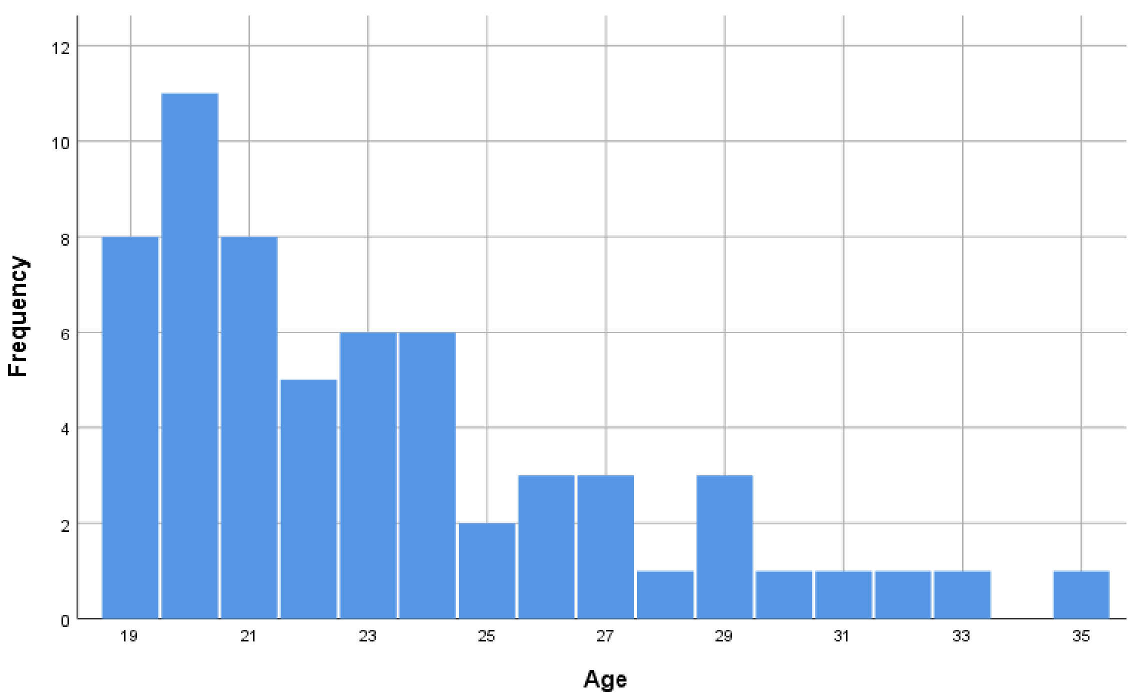


Figure 4.2. Participant's ages in original survey

After data collection, participants were separated into three age groups in order to aid data analysis.

Table 4.7

Descriptive Data for PRO-SLDS Scores by Age Group

Age Group	N	Mean	Min	Max	Std. Deviation
19 – 21	27	84.85	63.00	104.00	11.49
22 – 25	19	85.94	57.00	109.00	13.60
26 – 35	15	87.66	56.00	109.00	18.01
Total	61	85.88	56.00	109.00	13.77

Distribution of PRO-SDLS scores for the three groups fell into an approximately normal distribution, according to inspection of Q-Q Plots. This was further corroborated by Shapiro-Wilk's normality test ($p > .05$). However, variances in means between the three groups were heterogenous, as assessed by Levene's test ($p = .035$). Therefore, a one-way Welch ANOVA was performed to compare means between the groups. The null hypothesis for this research question was that there was no difference in PRO-SDLS mean scores between different age groups. Results of the ANOVA (Table 4.7) failed to reject the null hypothesis. Even though older participants showed higher PRO-SDLS means, as shown by descriptive statistics, the ANOVA indicates that this difference was not statistically significant ($p = 0.855$).

Table 4.8

Welch ANOVA Results for PRO-SDLS Scores by Age Group

	p	df1	df2	p
Welch	.158	2	30.05	.855

Research Question 5 – Are There Statistically Significant Differences in PRO-SDLS Scores by Academic Status?

Table 4.9

Descriptive Data for PRO-SDLS Scores by Academic Status

Status	N	Mean	Min	Max	Std. Deviation
Undergraduate - Sophomore	9	83.44	64.00	91.00	8.24
Undergraduate - Junior	15	88.06	63.00	104.00	13.61
Undergraduate - Senior	23	88.69	70.00	109.00	11.74
Graduate	14	80.50	56.00	109.00	18.60
Total	61	85.88	56.00	109.00	13.77

Shapiro-Wilk's test indicated that scores within that group were not normally distributed among sophomores (p = .029). Visual analysis of box plots indicated an outlier among sophomores, and that the distributions between groups were differently shaped (Figure 4.5).

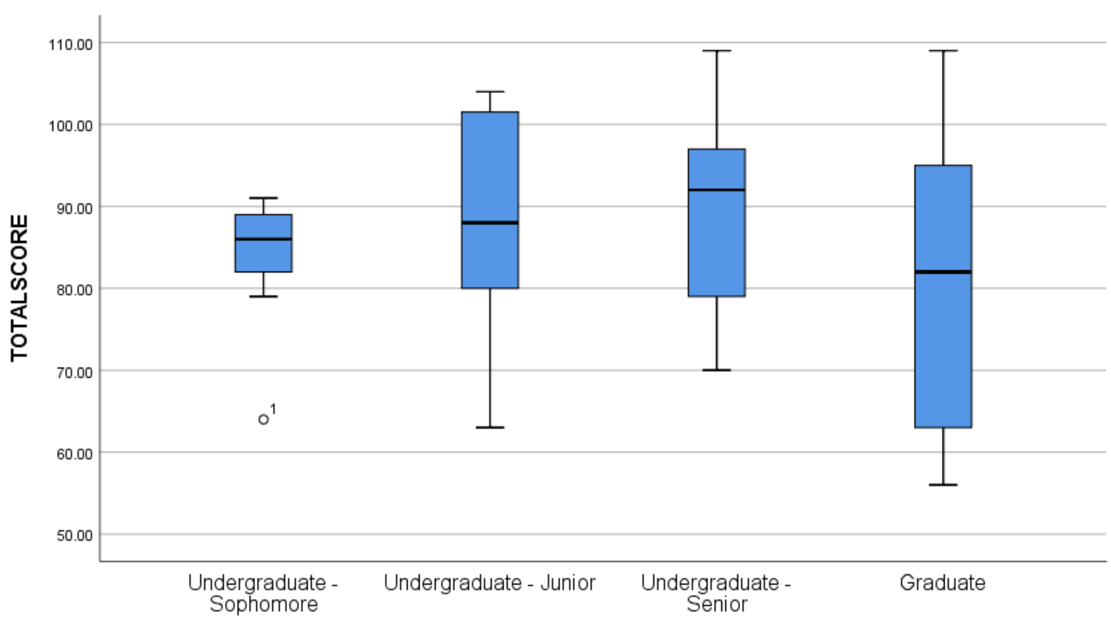


Figure 4.3. Box plots for PRO-SDLS scores by academic status

A Kruskal-Wallis H test was performed to analyze differences in PRO-SDLS scores. The null hypothesis for this research question was that the mean ranks of PRO-SDLS scores were not different between groups. The result of the H test showed weak evidence against the null hypothesis (p = .463). Seniors showed the highest mean PRO-SDLS scores, followed by juniors, sophomores, and graduate students, which had the lowest scores and the highest variability. However, the Kruskal-Wallis test indicates that the difference in mean ranks between groups was not statistically significant.

Table 4.10

Results of the Kruskal-Wallis H Test for PRO-SDLS Scores by Academic Status

Total N	61
Test Statistic	2.56
Degree Of Freedom	3
p	.463

Chapter 5 – Summary, Discussion and Recommendations for Further Study

Summary

This study was designed in order to measure the degree of self-direction of students from the Department of Computer Science and Software Engineering (CSSE) at Auburn University, and to determine if there were any statistically significant differences in the degree of self-direction by gender, ethnicity, age, and academic status (sophomore, junior, seniors, and graduate students). Self-direction was measured using the Personal Responsibility Orientation to Self-Directed in Learning Scale (PRO-SDLS) (Stockdale & Brockett, 2011).

Chapter 1 provided a brief introduction on the purpose of this study and described its five research questions:

1. How do Auburn University's CSSE students score in the PRO-SDLS?
2. Are there statistically significant differences in PRO-SDLS score by gender?
3. Are there statistically significant differences in PRO-SDLS score by ethnicity?
4. Are there statistically significant differences in PRO-SDLS score by age?
5. Are there statistically significant differences in the PRO-SDLS score among freshman, sophomore, junior, senior, and graduate CSSE students?

Chapter 2 described a literature review that analyzed the foundations of the study of self-direction in adult learning. It provided a rough chronological description of that field, including influential early works such as Houle's *The Inquiring Mind* (1963) and Tough's *The Adult's Learning Projects* (1971), popularization of research on self-direction in learning throughout the 70's, increased scrutiny and maturation of the construct of self-direction in learning throughout the 80's and 90's, and the impact of technology on self-direction from the mid 90's until today. It also described the Personal Responsibility Orientation model of self-direction in learning (Brockett & Hiemstra, 1991), which is the theoretical foundation for the PRO-SDLS. The review of the literature then narrowed its focus on the research about self-direction in learning among computer science, software engineering, and programming students. It found a relative lack of common ground, as the studies in the field did not share common theoretical foundations and generally did not reference each other. These works were categorized into four groups: the impact of self-directed learning methods on student learning and performance, development of instructional methods that foster self-direction, problem-based learning, and measures of learner self-direction.

Chapter 3 reported the methodology of this research project. An institutional IRB reviewed and approved the current study. With the assistance of staff from that department, CSSE students were recruited via email. Data collection happened through an anonymous electronic survey, built using Qualtrics. 61 participants completed the survey.

Chapter 4 provided the findings of this study. For the first research question, the mean PRO-SDLS score for all 61 participants was 85.88, but there was much variability in scores (Standard Deviation = 13.77).

For the second research question, an independent means t-test was performed. Descriptive statistics showed that males (M = 87.00, N = 44) had higher mean scores than females (M = 83.00, N = 17), but the t-test indicated that this difference was not statistically significant (p = 0.313).

For the third research question, an independent means t-test was performed. Descriptive statistics showed higher mean PRO-SDLS scores for Caucasians (M = 87.24, N = 37) compared to Non-Caucasians (M = 83.79, N = 24), but a t-test indicated that the difference was not statistically significant (p = 0.343).

For the fourth research question, a one-way ANOVA was performed. Participants aged 26 to 35 years had higher scores (M = 87.66, N = 15) than the other age groups, which included participants aged 22 to 25 (M = 85.94, N = 19) and 19 to 24 (M = 84.85, N = 27). However, results from the ANOVA indicated that the difference in means was not statistically significant (p = .855).

Finally, for research question five, a Kruskal-Wallis H test was performed. Seniors had the highest mean scores (M = 88.69, N = 23), followed by juniors (M = 88.06, N = 15), sophomores (M = 83.44, N = 9), and graduate students (M = 80.50, N = 14), but results form the Kruskal-Wallis test indicated that the difference in mean ranks between groups was not statistically significant.

Overall, the conclusion of this study was that there were no statistically significant differences in PRO-SDLS scores between different genders, ethnicities, age groups, as well as between sophomore, junior, senior, and graduate students.

Discussion

The mean PRO-SDLS score of participants in this study (M = 85.88) is generally comparable to the mean scores reported by other students. Stockdale (2003) reported slightly lower means (M = 84.05), as did a subsection of participants in Boyer et. al (2008) (M = 85.00). Meanwhile, Fogerson (2006) (M = 96.91), Hall (2011) (M = 91.17), Carlisle (2016) (M = 93.40), and Beeler (2018) (M = 95.76) all reported higher mean scores than this study.

The question that received the higher scores in the PRO-SDLS was “I often use materials I’ve found on my own to help me in a course”. Participants also scored high on a similar question ("I am unsure about my ability to independently find needed outside materials for my courses", 4^{th} highest score overall). This suggests that these students engage in self-direction in part to supplement and expand what they learn in class. However, the lowest-scored questions also indicate that the primary reason students complete course assignments is to obtain a grade. This quantitative study, thus, provides an indication of the relationship between self-direction and course assignments, but PRO-SDLS scores alone are not enough to provide further insights on this matter. A qualitative study that explored the process of self-direction in computer science learners and their reasons to do so would provide a clearer description of self-direction in the context of curriculum and course assignments.

When comparing mean scores by gender, the findings of this study were consistent with others in that no statistically significant difference was found (Stockdale, 2003; Hall, 2011; Carlisle, 2016). In all these studies, however, mean scores for females was higher than for males, which is in contrast with the findings of this study. A possible explanation for this is that females are historically underrepresented in STEM disciplines (Kanny, Sax, & Riggers-Piehl, 2014, Wang, Degol, & Ye, 2015), which might negatively impact how females perceive their own skills and achievements.

While other studies were consistent in their findings about gender, the same does not hold for ethnicity. Hall (2011) found that White students scored the highest means, but the differences between ethnicities (Black, Hispanic, and White) were not statistically significant. Conversely, Carlisle (2016) found that non-whites had higher means than whites, although tests on the difference in means between these groups were not reported. differences between. This study is in line with Hall's findings in that Caucasians scored higher on average, but the difference was not statistically significant. Since there is no clear consensus on the effects of ethnicity on PRO-SDLS scores, more research on this aspect would be beneficial.

Graduate students had the lowest mean scores, compared to sophomores, juniors, and seniors. Gaspar, Langevin, Boyer, & Armitage (2009) note that PRO-SDLS scores can reflect images participants have of themselves which have not been challenged. Thus, it is possible that undergraduates rate their own self-directedness higher because it has not been thoroughly tested yet, whereas the increased academic challenges graduate students face cause them to score lower. However, this issue is further complicated due to the higher scores of older participants the PRO-SDLS. The relationship between age, educational attainment, and self-direction of Computer Science learners is a complex matter that warrants further studies.

Recommendations for Further Study

While this study served as an exploration of the self-directedness of computer science learners using the PRO-SDLS, it also uncovered several possibilities for further research on that topic. First, a larger study on a similar population (college students) would be beneficial, in order to test if the same patterns in mean scores and statistical significance would be encountered. One of the reasons why descriptive data was provided even if post-hoc tests indicated a lack of statistical significance was to enable further studies on the subject to test whether statistical significance would be found in a larger sample.

This study measured self-direction quantitatively, and the motives, process, challenges and outcomes of self-direction were not explored. A qualitative study would provide interesting findings on these matters. It could help determine, for instance, where students go to find materials to supplement their courses, how much guidance computer science college students need to be self-directed, and whether there is a consistent need that drives these students to self-direction that could be addressed by their professors.

Current studies are not sufficient to determine the influence of race/ethnicity on PRO-SDLS scores. There is not enough data on the subject, and the studies that exist report contradictory findings. Although this study provided data on differences in PRO-SDLS scores between Caucasians and Non-Caucasians, studies that focus more deeply on this matter are warranted.

This study found that although older participants scored higher in the PRO-SDLS on average, graduate students displayed the lowest scores. Literature on adult education suggests that adults tend to self-direction as they age. However, findings from this study suggests that graduate students might face additional challenges that might call into question their ability for self-direction in learning. Further studies on this topic would be enlightening. A larger-scale quantitative study might test if graduate students consistently score lower than undergraduates in a large sample, and a qualitative study would more accurately describe what are the challenges that graduates students face.

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Appendix A – Permissions

Re: Master's Student Interested in PRO-SDLS

SS Susan Stockdale <sstockda@kennesaw.edu>
To Lucas De Almeida Adelino

Reply | Reply All | Forward | ...

Mon 1/13/2020 3:10 PM

You replied to this message on 1/14/2020 3:25 PM.

Age and Class and Online Learning.pdf 303 KB | Scoring A Learning Experience Scale.pdf 61 KB | A Learning Experience Scale (2).pdf 59 KB

Hi,
My best to you and Dr. Witte. Yes, you have my permission. I have attached it. Also, if you wish to more specifically define the learning domain (e.g., online classes) you may do so.

Also, I have also attached a recent article looking at an online learning environment.

Susan

Susan Stockdale, Ph.D.

Retired Professor of Educational Psychology and Middle Grades Education
Former Program Director, Woodrow Wilson Teaching Fellowship
Former Associate Dean of Graduate Studies, Bagwell College of Education

Kennesaw State University

Cell: 678 491 1020

From: Lucas De Almeida Adelino <lza0026@auburn.edu>
Sent: Sunday, January 12, 2020 7:33 PM
To: Susan Stockdale <sstockda@kennesaw.edu>
Subject: Master's Student Interested in PRO-SDLS

Dear Dr. Stockdale,

I hope your day is going well. My name is Lucas Adelino, and I am a graduate student at Auburn University. I am currently writing my master's thesis under the direction of Dr. James Witte. My research focuses on the self-directedness of computer science learners. Dr. Witte suggested that I use PRO-SDLS as the instrument to measure that. I'm writing this to kindly ask for your permission to use your instrument in my research. This would allow me to understand whether the common-sense view that computer science students are more apt to do self-directed learning actually holds true.

Thank you very much for your time. Please let me know if I can explain more about my thesis or provide any additional information.

Best regards,

Lucas Adelino

From: N Narayanan <narayanh@auburn.edu>
Sent: Thursday, January 9, 2020 5:03 PM
To: Lucas De Almeida Adelino <lza0026@auburn.edu>
Cc: Clint Lovelace <jcl0014@auburn.edu>
Subject: RE: Master's Thesis

Lucas
If you want to send a web-survey link to CSSE students, I am happy to forward the link to them after you obtain IRB permission. If you want to survey students in one or more specific courses or in person, I suggest that you talk with Mr. Clint Lovelace, who is our academic advisor (cc'd).
- HN

N. Hari Narayanan
John H. and Gail Watson Professor and Chair
Department of Computer Science & Software Engineering (CSSE)
Samuel Ginn College of Engineering
Auburn University
(334) 844-6312 | http://eng.auburn.edu/csse

From: Lucas De Almeida Adelino <lza0026@auburn.edu>
Sent: Thursday, January 9, 2020 3:44 PM
To: N Narayanan <narayanh@auburn.edu>
Subject: Master's Thesis

Dear Dr. Narayanan,

I hope your semester is off to a good start. My name is Lucas Adelino, I am a graduate student of Adult Education here at Auburn. I am working on my master's thesis, which is about the self-directedness of Computer Science learners, and I am interested in surveying students of Computer Science. In order to do that, support from faculty in the Computer Science department would be vital. If you're available to meet sometime tomorrow or next week to talk more about my thesis and strategies for reaching the students, I would really appreciate it. In any case, thank you very much for your attention!

Best regards,

Lucas Adelino

Appendix B – IRB Approval Notice

From: IRB Administration <irbadmin@auburn.edu>
Sent: Thursday, January 9, 2020 1:41 PM
To: Lucas De Almeida Adelino <lza0026@auburn.edu>
Cc: James Witte <witteje@auburn.edu>
Subject: Adelino Approval Exempt Protocol #19-522 EX 2001, "Measuring the Self-Directedness of Computer Science Students"

Use IRBsubmit@auburn.edu for protocol related submissions and IRBadmin@auburn.edu for questions and information.
The IRB only accepts forms posted at https://cws.auburn.edu/vpr/compliance/humansubjects/?Forms and submitted electronically.

Dear Mr. Adelino,

Your protocol titled "Measuring the Self-Directedness of Computer Science Students" was approved by the AU IRB as "Exempt" under federal regulation 45 CFR 46.101(b)(1,2).

Official notice:
This e-mail serves as notice the protocol has been approved. A formal approval letter will not be sent unless you notify us that you need one. By accepting this approval, you also accept your responsibilities associated with this approval. Details of your responsibilities are attached. Please print and retain.

Electronic Information Letter:
A copy of your approved protocol is attached. However you still need *to add the following IRB approval information to your information letter(s):* **"The Auburn University Institutional Review Board has approved this document for use from January 9, 2020 to ------- Protocol #19-522 EX 2001, Adelino"**

You must use the updated document(s) to consent participants. *Please forward the actual electronic letter(s) with a live link so that we may print a final copy for our files.*

Expiration:
Continuing review of this Exempt protocol is not required; however, all modification/revisions to the approved protocol must be reviewed and approved by the IRB.

When you have completed all research activities, have no plans to collect additional data and have destroyed all identifiable information as approved by the IRB, notify Office of the IRB via e-mail. A final report is NOT required for Exempt protocols.

If you have any questions, contact our office.

Best wishes for success with your research!

IRB Admin
Auburn University
115 Ramsay Hall
Auburn, AL 36849

Appendix C– IRB-Approved Information Letter

AUBURN UNIVERSITY

EDUCATIONAL FOUNDATIONS, LEADERSHIP AND TECHNOLOGY

INFORMATION LETTER

for a Research Study entitled

"Measuring the Self-Directedness of Computer Science Learners"

You are invited to participate in a research study about the degree to which computer science students learn computer science topics on their own. The study is being conducted by Lucas de Almeida Adelino, a master's student of Educational Foundations, Leadership, and Technology, under the direction of Dr. James Witte, professor of Educational Foundations, Leadership, and Technology at Auburn University. You are invited to participate because you are currently enrolled as an undergraduate or graduate student in a course offered by the Department of Computer Science and Software Engineering at Auburn University.

What will be involved if you participate? If you decide to participate, you will be asked to take an anonymous survey through Qualtrics. The survey will ask questions about your recent learning experiences and preferences. Your total time commitment will be approximately 15-20 minutes, which includes reading this document and taking the survey.

Are there any risks or discomforts? The only risk associated with participating in this study is a loss of confidentiality. There will be no costs, compensation, or direct benefits to you for your participation. Information collected through your participation may be used for the advancement of a master's thesis, research publications or professional presentations.

If you change your mind about participating, you can withdraw at any time prior to submitting your survey by closing your browser. Your participation is completely voluntary, meaning you are not required to take part in this study. Once you submit your survey, your information cannot be withdrawn because it will not be identifiable. Your decision about whether to participate will not jeopardize any relationship you may have with Auburn University.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide by not granting access to the raw data obtained in the survey to any parties, except for the Principal Investigator and the Faculty Principal Investigator. Once this study is complete, the data will be destroyed.

The Auburn University Institutional Review Board has approved this Document for use from
1/9/2020 to --------------
Protocol # 19-522 EX 2001

4036 Haley Center, Auburn, AL 36849; Telephone: 334-844-4460; Fax: 334-844-3072

www.auburn.edu

If you have questions about this study, *please ask them now or* contact Lucas de Almeida Adelino at lza0026@auburn.edu or Dr. James Witte at witteje@auburn.edu.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, THE DATA YOU PROVIDE WILL SERVE AS YOUR AGREEMENT TO DO SO. THIS LETTER IS YOURS TO KEEP.

Survey link: https://auburn.qualtrics.com/jfe/form/SV_e99xUqVRlr0mhIV

LucasAdelino 12/13/2019

Investigator's signature Date

LUCAS DE ALMEIDA ADELINO

Print name

The Auburn University Institutional Review Board has approved this Document for use from 1/9/2020 to --------------
Protocol # 19-522 EX 2001