Computer Science Students' Perceptions of Social Presence Related to Student Retention in Online Degree Programmes: A Quantitative Ex Post Facto Correlational Study

by

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Declaration

I declare that Computer Science Students' Perceptions of Social Presence Related to Student Retention in Online Degree Programmes: A Quantitative Ex Post Facto Correlational Study is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted this dissertation to originality checking software and that it falls within the accepted requirements for originality. I further declare that I have not previously submitted this work, or part of it, for examination for another qualification at Unisa or at any other higher education institution.

Joshua D. Reichard

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I would like to acknowledge the support of my supervisor, Prof. Mishack T. Gumbo, who provided thorough critical-constructive feedback on this dissertation, and all the professors throughout my graduate and doctoral education who have patiently taught me the art of research design and the finesse of research statistics. I would also like to acknowledge my lifelong friend and colleague, David Richardson who is the best-minded computer scientist I know, and my uncle Shawn Blake, who inspired me towards the field of computer science at a young age and mentored me throughout my career. I am pleased to have circuitously found my way back through technology education.

Dedication

This dissertation is dedicated to all the undergraduate computer science students I have served in online degree programmes. Please remember,

"Computer science has as much to do with computers as astronomy has to do with telescopes."

– *Anonymous Quote Inaccurately Attributed to Countless Computer Scientists*

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Abstract

This study was an examination of the relationship between social presence, student satisfaction, and persistence in online computer science undergraduate degree programmes. The problem is twofold: how social presence is perceived by students and the extent to which those perceptions relate to persistence and satisfaction related to the problem of attrition in online undergraduate computer science degree programmes. This study is significant because it seeks to address two interrelated objectives: firstly, to specifically examine perceptions of social presence (and how it relates to persistence and satisfaction) among students who have studied computer science online, and secondly, to contribute research to the body of literature seeking to validate measures of the social presence construct. As a quantitative ex post facto correlational study using archival data from the Computing Research Association's Center for Evaluating the Research Pipeline (CERP) Data Buddies dataset, Spearman's rank procedure was applied to test non-normal data that did not meet assumptions tests. All three null hypotheses were rejected ($p < 0.01$). The findings suggested a significant positive relationship between composite social presence scores and persistence and satisfaction ratings among online computer science students. The post hoc procedures revealed weak effect sizes but strong power due to the large sample size ($n = 1{,}646$). The three subconstructs, social presence, sociability, and social space, were found to have strong internal consistency and reliability. The findings suggest that students with a higher social presence in online courses tend to persist in their studies and are more satisfied. However, the weak correlation coefficient and size of the effect suggest that other factors may also influence students' experiences in online undergraduate computer science degree programmes and that social presence should not be overestimated as a unilateral factor related to student persistence and satisfaction. This study's findings are consistent with previous research on social presence theory and the Community of Inquiry framework. Limitations include a correlational design, non-normality of data, nonparametric tests, small effect sizes, and a narrow scope of measures. By addressing a problem in computer science education, this study might inspire constructive changes in instructional practices by technology educators, especially those teaching computer science online.

Key terms

Social presence, computer science, attrition, persistence, satisfaction, retention, Community of Inquiry, sociability, social space, technology

Isishwankathelo

Olu phando luphononononge ubudlelwane phakathi kokuba yinxalenye yoluntu kwi-intanethi, ukwaneliseka kwabafundi, kunye nokuzingisa kwiinkqubo zangeintanethi zemfundo yesidanga sokuqala sezeNzululwazi yeKhompyutha. Ingxaki ibintlobombini: indlela yokuba yinxalenye yoluntu kwi-intanethi okubonwa ngayo ngabafundi, nokuba ezo mbono zinxulumene kangakanani nokuzingisa kunye nolwaneliseko nanjengoko zinxulumene nengxaki yokuncipha ngokuthe ngcembe kwabafundi kwezo nkqubo. Olu phando lubalulekile nanjengoko lukhangela ukusombulula iinjongo ezimbini ezinxulumeneyo: okokuqala, ukuphonononga ngokukodwa iimbono zokuba yinxalenye yoluntu kwi-intanethi (nendlela ezinxulumene ngayo nokuzingisa kunye nokwaneliseka) phakathi kwabafundi abafunda iNzululwazi yeKhompyutha kwi-intanethi, kwaye okwesibini, kukwenza igalelo lophando kuncwadi olusele lukho olufuna ukuqinisekisa imilinganiselo yengcingane yokuba yinxalenye yoluntu kwi-intanethi. Nanjengophando lweenkcukachamanani lolungelelaniso lwasemva kokuyinyani (*quantitative ex-post facto correlational study*) olusebenzisa idatha eselungcinweni lwengqokelela yeenkcukacha ye*Computing Research Association's Center for Evaluating the Research Pipeline (CERP) Data Buddies*, kusetyenziswe inkqubo yokubeka ngokodidi kaSpearman ukuvavanya idatha engaqhelekanga engakhange ihlangane neemvavanyo zoqikelelo. Zontathu iingcinga ezithathwa njengenyaniso engekaqinisekiswa ezingenanto/ezingunothi ziye zakhatywa ($p < 0.01$). Iziphumo ziphakamise ubudlelwane obulungileyo obubalulekileyo phakathi kwamanqaku adityanisiweyo okuba yinxalenye yoluntu kwi-intanethi nokuzingisa kunye nokuhlela kokwaneliseka phakathi kwabafundi bezeNzululwazi yeKhompyutha kwi-intanethi. Iinkqubo zasemva kwesiganeko zibonise ubungakanani befuthe elibuthathaka kodwa zikwabonise namandla amakhulu ngenxa yobukhulu besampuli ($n = 1\ 646$). Nangona kunjalo, ukuba buthathaka kokuhambelana kwamanani andisayo kunye nobungakanani befuthe kubonisa ukuba eminye imiba inganempembelelo kumava abafundi kwiinkqubo zangeintanethi zesidanga sezeNzululwazi yeKhompyutha, kwaye ukuba yinxalenye yoluntu kwi-intanethi akufanelekanga ukuba kuqikelelwe ngokugqithiseleyo nanjengempembelelo enye enxulumene nokuzingisa nokwaneliseka kwabafundi. Iziphumo zolu phando ziyahambelana nophando lwangaphambili malunga nethiyori yokuba yinxalenye yoluntu kwi-intanethi kunye nesikhokelo se*Community of Inquiry*. Izithintelo zibandakanya uyilo lokuhambelana, ukungabikho kwisiqhelo kwedatha, iimvavanyo ezenza iingqikelelo ezimbalwa (*nonparametric tests)*, ubungakanani bobuncinane befuthe, kunye nobumxinwa bommandla wemilinganiselo. Ngokujongana nengxaki

kwimfundo yezeNzululwazi yeKhompyutha, olu phando lungakhuthaza utshintsho olwakhayo kwiinkqubo zokufundisa zootitshala bezobuchwepheshe – ngakumbi abo bafundisa iNzululwazi yeKhompyutha kwi-intanethi.

Amagama angundoqo

ukuncipha ngokuthe ngcembe, i*Community of Inquiry*, inzululwazi yekhompyutha, ukuzingisa, ukugcinwa, ulwaneliseko, ukuba ngumntu wabantu, ukuba yinxalenye yoluntu kwi-intanethi, iqonga loluntu, ubuchwepheshe

Opsomming

Hierdie studie het die verhouding tussen sosiale teenwoordigheid, studentetevredenheid en volharding in aanlyn voorgraadse Rekenaarwetenskap-programme ondersoek. Die probleem was tweevoudig: hoe sosiale teenwoordigheid deur studente waargeneem is, en die mate waartoe daardie waarnemings oor volharding en tevredenheid geassosieer word met die probleem van studente wat nie hierdie programme voltooi nie. Hierdie studie is betekenisvol aangesien dit daarna gestreef het om te kyk na twee onderling verwante doelwitte: eerstens, om in die besonder die waarnemings van sosiale teenwoordigheid te ondersoek (en hoe dit verband hou met volharding en tevredenheid) onder studente wat Rekenaarwetenskap aanlyn studeer het, en tweedens, om ’n bydrae te lewer tot navorsing vir die vakliteratuur om die maatreëls van die sosiale teenwoordigheidkonstruksie te bekragtig. As ’n kwantitatiewe terugskouend gesiene korrelasiestudie wat argiefdata gebruik van die Rekenaarnavorsingsassosiasie *(Computing Research Association)* se Sentrum vir die Evaluering van die Navorsingspyplyn *(Centre for Evaluating the Research Pipeline (CERP)) Data Buddies*-datalêer, is Spearman se rangprosedure toegepas om nie-normale data te toets wat nie voldoen aan aannames-toetse nie. Al drie nulhipoteses is verwerp ($p < 0,01$). Die bevindings suggereer ’n beduidende positiewe verhouding tussen saamgestelde sosiale teenwoordigheidstellings en volharding- en tevredenheidsgraderings onder aanlyn Rekenaarwetenskap-studente. Die *post hoc*-prosedures het swak effekgroottes onthul maar sterk krag weens die groot steekproefgrootte ($n = 1\ 646$). Daar is gevind dat die drie subkonstruksies – sosiale teenwoordigheid, geselligheid en sosiale ruimte – oor ’n sterk interne konsekwentheid en betroubaarheid beskik. Die bevindings dui aan dat studente met ’n hoër sosiale teenwoordigheid in aanlyn kursusse geneig was om te volhard in hulle studie en meer tevrede was. Die swak korrelasiekoëffisiënt en grootte van die effek dui aan dat ander faktore ook studente se ervarings van aanlyn voorgraadse Rekenaarwetenskap-programme kan beïnvloed, en dat sosiale teenwoordigheid nie oorskat moet word as ’n eensydige faktor wat verband hou met studentevolharding en -tevredenheid nie. Hierdie studie se bevindings is verenigbaar met vorige navorsing oor sosiale teenwoordigheidteorie en die “Gemeenskap van Navrae”-raamwerk (“*Community of Inquiry” framework*). Beperkings sluit in ’n korrelasieontwerp, die nie-normaliteit van data, klein effekgroottes en ’n beperkte omvang van maatreëls. Deur te kyk na ’n probleem in Rekenaarwetenskap-opvoeding kan hierdie studie ’n inspirasie wees vir konstruktiewe veranderings in die instruksionele praktyke van tegnologie-opvoeders – veral dié wat Rekenaarwetenskap aanlyn onderrig.

Sleutelterme

Nie-voorsetting, “Gemeenskap van Navrae” *(“Community of Inquiry”*), Rekenaarwetenskap, volharding, retensie, tevredenheid, geselligheid, sosiale teenwoordigheid, sosiale ruimte, tegnologie

Chapter 1 Introduction to the Study

1.1 Introduction

In computer-mediated communication (CMC), *social presence* is a thoroughly researched concept, yet remains elusive to, and contested among, researchers (Kreijns, 2021; Lowenthal & Snelson, 2017; Öztok & Kehrwald, 2016). The concept has been applied to all forms of telecommunications, especially to computer-based education and online learning (Poth, 2018; Mykota, 2017; Lowenthal & Snelson, 2017; Kerhwald, 2008). However, the concept (and its interrelated issues in online learning) has not been explicitly examined among undergraduate students who have studied the subject of computer science online (Yang, Sithole, McCarthy & Bucklein, 2018). This study seeks to address this gap in the literature. Social presence theory, the theoretical framework of this study, is grounded in decades of scholarly research and debate concerning a precise definition of social presence and its measurement in telecommunications. Social presence was first conceptualised by John Short, Ederyn Williams and Bruce Christie in *The Social Psychology of Telecommunications* (1976) as the relative degree of "salience" of interpersonal relationships mediated by telecommunications (p. 65). For Short et al. (1976), social presence was grounded in two sociological subconstructs, which are intimacy and immediacy. Gunawardena (1995) defined social presence as the degree to which a person is perceived as "real" in telecommunications. While the notion of "realness" has persisted to a large degree, since that time, others have attempted to expand on the theoretical construct of social presence and to devise instruments to measure it (Kreijns, Xu & Weidlich, 2021; Lowenthal & Snelson, 2017; Öztok & Kehrwald, 2016; Kerhwald, 2008). Karel Kreijns is arguably the foremost scholar on social presence theory and has devised instruments to measure it (2011) and synthesised the predominant literature to nuance its definitions (2021).

The background of the problem is based on numerous studies in the literature which suggest that low pass rates, low student satisfaction, and high attrition in science, technology, engineering, and mathematics (STEM) fields are "the most significant problems" (Zahedi, Ross, Ohland & Lunn, 2020, p. 1) facing related industries (Bengasai & Pocock, 2021; Whitcomb & Singh, 2021; Ajoodha, Jadhav & Dukhan, 2020; Lopez & Hassoun, 2022). The problem is therefore twofold: firstly, how social presence is perceived by students, and the extent to which those perceptions relating to persistence and satisfaction, might reveal otherwise unknown multifaceted factors of attrition in online undergraduate computer science

degree programmes (Zahedi et al., 2020; Boston, Ice & Gibson, 2011); and secondly, the contested construct of social presence demands continued validation, as called for by seminal scholars in the field (Kreijns, Xu & Weidlich, 2021; Lowenthal & Snelson, 2017; Kerhwald, 2008). While the problem is global (Bengasai & Pocock, 2021), this study focuses on students in approximately 140 computer science programmes at universities in the United States of America.

This quantitative ex post facto correlational study examines factors of social presence experienced by undergraduate computer science students in online learning programmes. This study used archival data from an instrument administered to undergraduate students, including items related to social presence, student persistence, and student satisfaction. Items on the instrument were aligned with the theoretical and conceptual frameworks grounded in social presence theory (Kreijns et al., 2021).

1.2 Rationale for the Study

This study is significant because it seeks to address two interrelated objectives: primarily, to specifically examine perceptions of social presence (and how this relates to persistence and satisfaction) among students who have studied computer science online, and secondarily, to contribute research to the body of literature seeking to validate measures of the social presence construct. Seminal scholars attempting to define and measure social presence have suggested that high degrees of perceived social presence are related to student satisfaction, success, and retention (Moallem, 2015; Kerhwald, 2008).

Firstly, it is “crucial to specifically explore the variables that contribute to positive academic outcomes in computing fields” and to find ways to improve completion and graduation rates, “especially among marginalized groups” (Zahedi et al., 2020, p. 2). Factors related to the problem of attrition in computer science programmes need to be examined and understood (Ajoodha et al., 2020; Zahedi, Ebrahiminejad, Ross, Ohland & Lunn, 2021). Because there is a high rate of attrition for computer science majors in general (Chen, 2013), especially among students who have studied computer science online (Ajoodha et al., 2020), this study might help technology educators develop educational methods that can help improve student satisfaction and retention. The dataset used for this study was designed to “drive institutional

change" related to the academic field of computer science, particularly toward broadening access to underrepresented students (Lewis, Camp, Horton, Reed & Tamer, 2021).

Secondly, this study is also an attempt to evaluate the internal validity of factors that define the social presence construct and to evaluate the extent to which perceptions of social presence are related to student satisfaction, specifically in online computer science programmes. Although the data are specific, using data from an instrument not intended initially to measure social presence may offer a unique perspective on debates concerning its definition and measurement (Kreijns et al., 2021; Kerhwald, 2008).

Finally, this study is relevant to the field of technology education because it addresses a problem in computer science education that might lead to constructive changes in instructional practice by technology educators. Gumbo (2016) defines technology education as a field of study exploring the relationship between science and technology and implementing technology in the curriculum. By examining the data from a widely used instrument designed for computer science students through the theoretical framework of social presence, this study provides a unique perspective on a perennial problem in technology education.

1.3 Problem Statement

For this study, the problem is twofold: firstly, to determine how social presence is perceived by students, and the extent to which those perceptions relate to persistence and satisfaction might reveal otherwise unknown multifaceted factors of attrition in online undergraduate computer science degree programmes (Lopez & Hassoun, 2022; Takács e al., 2022; Zahedi et al., 2020); and secondly, to investigate how the contested construct of social presence demands continued validation, as called for by seminal scholars in the field (Kreijns et al., 2021; Lowenthal & Snelson, 2017; Öztok & Kehrwald, 2016; Kreijns, Kirschner, Jochems & Van Buuren, 2011; Kehrwald, 2008). Computer science has historically had the highest attrition rates among all STEM fields (Syahira et al., 2019; Chen, 2013). The problem is examined as ex post facto, using data from an instrument to which the subconstructs of social presence are abstracted, aligned, and tested for statistically significant correlation.

STEM education presents unique challenges and demands, particularly for minority and underrepresented students, which can contribute to higher attrition rates in computer science

programmes. For example, Whitcomb, Cwik and Singh (2021) discuss the structural inequities that marginalised students face in higher education and the challenges to creating an equitable and inclusive learning environment that takes advantage of student assets and promotes a high sense of belonging. Moreover, Miles, Brockman and Naphan-Kingery (2020) found that Black doctoral students and postdocs in STEM programmes faced racial microaggressions that challenged their sense of belonging and identities as engineers due to stereotypes and institutional climates and emphasised the need for inclusive initiatives to combat exclusionary practices. Understanding such challenges and how they relate to the broader STEM movement supports the development of effective strategies to promote student success in computer science. STEM education more broadly contextualizes students' specific challenges in computer science programmes. Such a broad perspective may help frame the context of this study and ultimately address the problem of attrition and its relation to perceptions of social presence in online learning (Whitcomb et al., 2021).

While this study focuses on the problem in its context of the United States, it is a global problem. Attrition in computer science is also a problem for universities throughout Africa. Attrition among students in the sciences, computer science included, is a particular challenge for African universities (Lopez & Hassoun, 2022; Ajoodha & Dukhan, 2020). Student persistence and retention, the antidotes of attrition in such fields, concern higher education institutions, “not only in South Africa, but globally” (Bengasai & Pocock, 2021, p. 1).

1.4 Research Questions

Variables addressed in the research questions and hypotheses are grounded in the theoretical framework based on the literature surrounding social presence. The framework is aligned to items on the Center from Evaluating the Research Pipeline (CERP) survey instrument. Composite social presence scores were used to measure students’ perceptions of social presence.

Overarching Research Question: What is the relationship between undergraduate computer science students’ perceptions of social presence and retention in online degree programmes in United States universities?

The research questions guide this study's hypotheses, design, and data collection and analysis. Under the overarching research question stated above, the three research questions for this study are as follows:

Research Question 1 (RQ1): What relationship, if any, exists between composite social presence scores and persistence ratings among students who have studied computer science online according to aligned items on the CERP instrument?

Research Question 2 (RQ2): What relationship, if any, exists between composite social presence scores and student satisfaction ratings among students who have studied computer science online according to aligned items on the CERP instrument?

Research Question 3 (RQ3): What relationship, if any, exists in the subconstructs of social presence, sociability, and social space among perceptions of students who have studied computer science online according to aligned items on the CERP instrument?

RQ1 seeks to identify what relationship, if any, exists between the perception of social presence and student persistence within the dataset. In addition, this question encompasses RQ2, which seeks to identify what relationship exists, if any, between student satisfaction ratings and student perceptions of social presence. Finally, RQ3 is incidental and attempts to determine what relationship, if any, exists between the aligned subconstructs of social presence, sociability, and social space, as aligned to items on the CERP instrument.

1.5 Research Aim and Objectives

This study aims to examine the extent to which computer science students perceive social presence in online undergraduate degree programmes. This study also uniquely applies a theoretical framework based on the literature to a credible instrument and its resultant data with abstracted measures of social presence, which could foster additional replicable research using the same or a similar conceptual framework and instrument in the future. The research objectives of this study are:

Research Objective 1 (RO1): To evaluate the extent of the relationship between composite social presence scores and student persistence scores among students who have studied computer science online according to aligned items on the CERP instrument.

Research Objective 2 (RO2): To ascertain the extent of the relationship between composite social presence scores and student satisfaction ratings among students who have studied computer science online according to aligned items on the CERP instrument.

Research Objective 3 (RO3): To assess the extent of the relationship between the subconstructs of social presence, sociability, and social space among perceptions of students who have studied computer science online according to aligned items on the CERP instrument. The overarching aim of this study is aligned with the overarching research question. RO1 is aligned with RQ2. RO3 is incidental to this study but will contribute to the literature concerning the definition and measurement of social presence and is therefore aligned to RQ3. The objectives of this study also include deducing recommendations for technology educators based on the findings. Because the third objective, specifically, relates to contributing to the validation of the measurement of social presence, the findings should contribute to the literature accordingly in journals where social presence has been a topic of interest. In sum, the aims are to answer the research questions, measure the hypotheses, report the results, and contribute to the literature.

1.6 Hypotheses

The hypotheses for this study are appropriate for an ex post facto correlational design because they are intended to test the relationships between two or more continuous variables (Creswell, 2018). The variables for the hypotheses are grounded in and derived from the literature. The theoretical framework establishes the alignment of social presence, sociability, and social space subconstructs to measurable items on the CERP instrument. The dependent variables are continuous interval data, and the independent variables are ordinal or nominal data. The hypotheses are stated as follows:

$H_0$1: No statistically significant relationship exists between composite social presence scores and persistence ratings among students who studied computer science online, according to aligned items on the CERP instrument.

H_a1: A statistically significant relationship exists between composite social presence scores and persistence ratings among students who studied computer science online, according to aligned items on the CERP instrument.

$H_0$2: No statistically significant relationship exists between composite social presence scores and student satisfaction ratings among students who studied computer science online according to aligned items on the CERP instrument.

H_a2: A statistically significant relationship exists between composite social presence scores and student satisfaction ratings among students who studied computer science online according to aligned items on the CERP instrument.

$H_0$3: No statistically significant relationship exists between the subconstructs of social presence, sociability, and social space among perceptions of students who studied computer science online according to aligned items on the CERP instrument.

H_a3: A statistically significant relationship exists between the subconstructs of social presence, sociability, and social space among perceptions of students who studied computer science online according to aligned items on the CERP instrument.

1.7 Research Methodology

This study utilised a quantitative methodology based on an ex post facto correlational design. This study did not directly involve human participants by using publicly available archival data from the Computing Research Association's Center for Evaluating the Research Pipeline (CERP). Variables derived from the data points aligned with theoretical and conceptual frameworks were tested using appropriate correlational statistical procedures. Parametric statistical procedures, or their nonparametric equivalents, were conducted using IBM SPSS (Statistical Package for the Social Sciences). Assumptions and post hoc tests were also conducted.

1.8. Definition of Key Concepts

Concise definitions of key concepts enhance the precision of a scientific study (Creswell, 2018). The following definitions of key concepts were used in this study. Definitions ensured alignment with the existing body of literature and consistency throughout this study.

Undergraduate computer science programmes

These are formal sequences of instruction offered by accredited postsecondary institutions of higher education leading to a degree in computer science or related field (information technology, cybersecurity, etc.), e.g., at bachelor's levels (in the United States), National Qualifications Framework levels seven and eight in South Africa, or levels five and six in the British Commonwealth (Trapani & Hale, 2020).

Online learning

Online learning is the structure of formal learning processes between students, instructors and content, delivered by an accredited academic institution, using computer-mediated communication tools via the Internet (Singh & Thurman, 2019).

Social presence

As a subconstruct, social presence is a psychologically unique phenomenon whereby people perceive others as being physically 'real' while interacting using computer-mediated communications tools and other electronic platforms. While the definition of the concept is contested, the definition provided by Kreijns et al. guided this study. As a composite construct, social presence is the interrelated and inseparable subconstructs of social presence, sociability, and social space (Kreijns et al., 2021, p. 163).

Sociability

Sociability is the extent to which computer-mediated communication tools and electronic platforms "allow for the expression of social presence and the experience of it as well as for the emergence of social space" (Kreijns et al., 2021, p. 141). Sociability is a feature of the tool or technological medium itself.

Social space

Social space is a "sense of community, group climate, mutual trust, social identity, and group cohesion" that individuals feel when using CMC tools (Kreijns et al., 2021, p. 163). Social space is a sociological construct.

Attrition

Attrition is the voluntary or involuntary withdrawal of students from courses or formal learning programmes and the inverse of retention; attrition may be expressed as a rate by institutions (Syahira et al., 2019).

Retention

Retention is the net measure of students who persist in courses and degree programmes versus students who withdraw from them, and it is the inverse of attrition; retention may be expressed as a rate by institutions (Seery, Berreda & Hein, 2021; Tight, 2020; Simpson, 2003).

Persistence

Persistence is "the intention to complete the online course in which the student is enrolled" (Lakhal, Khechine & Mukamurera, 2021, p. 4).

Satisfaction

Satisfaction is the aggregation of students' attitudes toward the sum of their learning experiences (Elliott & Shin, 2002).

1.9 Chapter Outline

The following chapters comprise this study:

Chapter 1: This introductory chapter serves as a window into the dissertation. It orientates the reader by identifying the problem that leads to the problem statement and research questions, objectives, and hypotheses. The rationale for the study is given in this chapter. An overview of the research methodology is also given. The chapter ends by describing the key concepts and outlining the ensuing chapters.

Chapter 2: This chapter is a comprehensive review of the literature on the theoretical framework of social presence theory, starting with the seminal definitions by Short et al. (1976) and modern interpretations by Kreijns et al. (2021). Counterarguments, critical reviews, and

connections to other theories include symbolic interaction, social situationism, Piaget's and Papert's social constructivism, collaborative online learning, and the CoI framework. The influence of *Ubuntu* philosophy and social media platforms on social presence theory is also discussed, setting the groundwork for understanding the social aspects of online learning and their possible relationships with student retention.

Chapter 3: This chapter is a review of the literature on student attrition in online undergraduate computer science degree programmes, highlighting relevant connections to social presence theory. Theories of motivation, student persistence, satisfaction issues, instructional design theories in the context of online learning, along with notable studies on student retention, are explored. Literature is synthesised through the lens of social presence theory, aids in understanding the factors influencing student retention in online computer science programmes, and sets the groundwork for the study's research methodology.

Chapter 4: This chapter delineates the research methodology and design of the study, detailing the population, sample selection, variables related to social presence theory, and the application of the CERP instrument. Procedures for data collection, preparation, analysis, and interpretation address reliability and validity issues. The study's ethical considerations, limitations, and delimitations are presented, underscoring the importance of maintaining ethical standards while acknowledging potential impacts on the study's reliability and validity.

Chapter 5: This chapter explains the data collection, preparation, and analysis procedures, including obtaining the CERP dataset, importing it into IBM SPSS, and formulating unique variables for constructs and subconstructs. Various analysis methods were employed, but due to the data failing to meet parametric assumptions, the study adopted the Spearman rank procedure, rejecting all three null hypotheses. An assessment of reliability and validity, indicating a moderate to strong reliability for each social presence subconstruct, and admitting some construct and criterion validity weaknesses, despite generally defensible validity, are articulated.

Chapter 6: This study implies that an improved social presence in online courses, achieved through prompt feedback, easy-to-use platforms, and various interactive opportunities, is positively related to student satisfaction and persistence. In the context of online computer science degrees, supportive social space can motivate marginalised students, especially when they have access to shared resources like mentorship. However, considering the white male dominance in computer science, the challenges traditionally underrepresented students face demand further examination.

Chapter 7: This chapter highlights conclusions and recommendations for future research. Despite certain limitations like the focus on US students and weak to moderate correlation coefficients, the findings indicate that higher perceived social presence may improve student satisfaction and persistence. Findings suggest that social presence is an aspect of successful online learning environments and could be used to improve satisfaction and lower attrition rates, especially for underrepresented students in computer science.

1.10 Summary

This introductory chapter has provided background concerning the problem of attrition among computer science students in online learning programmes and a formal problem statement. Firstly, research questions, aims, and objectives were formulated. Then, testable hypotheses related to the research questions were presented. Next, a summary of the quantitative research methodology and ex post facto correlational design was previewed. Finally, definitions for key concepts used throughout the study were delineated. The next chapter is a review of the literature surrounding the theoretical and conceptual frameworks for the study related to social presence theory.

Chapter 2 Social Presence Theory in Online Learning

2.1 Introduction

This chapter comprises a review of the literature related to the chosen theoretical framework for the study, social presence theory. The literature review is organised into seven major sections, which include an overall formulation of the theoretical framework around seminal definitions of social presence theory, a contemporary formulation of social presence by Kreijns et al. (2021; 2011), classical sociological theories augmenting social presence, which are social constructionism and social constructivism, the Community of Inquiry Framework (CoI), collaborative learning and connectivism, and social media technologies. Social presence was thoroughly explored as the main theory framing the study. Other social learning theories were also explored to augment social presence. Justification of the theory and how it applies in the study are given. The chapter also shows how the augmenting theories fit within social presence.

The conceptual framework used in this study is based on the three interrelated constructs that Kreijns et al. (2021) identified to conceptualise social presence more precisely: social presence, sociability, and social space. Sociability is linked to computer-mediated CMC tools, software, and hardware, while social space considers a sense of community, mutual trust, social identity, and group cohesion. The conceptual framework is inductive and deductive, derived from the overarching theoretical framework of social presence theory, and defined in terms of more specific subconstructs within the conceptual framework. Each subconstruct relates to specific theories reviewed throughout this chapter (see Table 2.1).

Table 2.1 Synthesis of Theories from the Literature

Subconstruct	Related Theories
Sociability	Symbolic interactionism, connectivism, social networking and social media, immersive qualities, and contextual properties
Social Space	Social situationism, CoI framework, Piaget's constructivism, Papert's constructionism, collaborative learning, Ubuntu
Social Presence	Goffman's dramaturgy, social situationism, Bandura's social learning theory

Therefore, this chapter explores the three subconstructs of social presence theory: sociability, social space, and social presence, and the related theories that complement them. Sociability is associated with symbolic interactionism, connectivism, social networking and social media, immersive qualities, and contextual properties. Social space is related to social situationism, CoI framework, Piaget's constructivism, Papert's constructionism, and collaborative learning. Finally, as a subconstruct, social presence is compatible with Goffman's dramaturgy, social situationism, and Bandura's social learning theory.

2.2 Social Presence Theory

Theoretical frameworks provide structure to define "philosophically, epistemologically, methodologically, and analytically" appropriate approaches to a research study (Grant & Osanloo, 2014, p. 13). Theoretical frameworks can be applied to various research methodologies and are appropriate for quantitative studies. They serve to justify why research questions are "proposed to be answered in a particular way" and "why certain variables are more important than others" (Ngulube, Mathipa & Gumbo, 2015, p. 60). The social presence theory is the primary theoretical framework guiding this study.

Social presence is the degree to which individuals communicating through technological media are perceived as real persons by one another (Kreijns et al., 2021; Kreijns et al., 2011; Short et al., 1976). Social presence is primarily associated with computer-mediated communication (CMC) technologies. In recent decades, it has been closely associated with online learning, especially group learning in online environments (Kreijns et al., 2021). Pointing further back to Short, Williams and Christie (1976), Kreijns et al. (2011) note that the interpersonal principles of social presence theory apply to any communication exchange regardless of the technological medium. The concept of social presence has been a topic of interest in research related to online teaching and learning since the late 1990s. Furthermore, social presence is relevant to other theoretical approaches to online learning in synchronous and asynchronous environments, such as social constructionism and "computer-supported collaborative learning environments," sometimes called CSCLEs (Kreijns, Kirschner & Jochems, 2003, p. 335).

For Short et al. (1976), social presence influences the technological medium by which people communicate and affects the nature and purpose of interpersonal interactions. Therefore, social presence was originally conceived as a "quality of the [technological] medium itself" (Short et

al., p. 65). In other words, some telecommunications media inherently afford more social presence than others. Accordingly, Short et al. (1976) devised a primitive instrument with four seven-point bipolar scales intended to rate various telecommunications media according to respondents' experiences with them. These scales included unsociable to sociable, insensitive to sensitive, cold to warm, and impersonal to personal (p. 66).

The earliest definitions of social presence were nuanced. Short et al. (1976) also identify two types of social behaviours, or dispositions, to measure social presence, i.e., immediacy and intimacy. Immediacy is a "measure of the psychological distance which a communicator puts between [themselves] and the object of [their] communication, [their addressee, or [their own] communication" (p. 72). Short et al.'s notion of immediacy was based on earlier social-psychological research. Wiener and Mehrabian (1968) define it as interpersonal expressions of availability, closeness, and interest. Intimacy is a "function of eye-contact, proximity, conversation topic, and so on; changes in one will produce compensating changes in the others" (Short et al., 1976, p. 53). Short et al.'s (1976) notion of intimacy was also based on earlier social-psychological work by Argle and Dean (1965), who saw intimacy as a kind of equilibrium according to which social actors negotiate between intimacy and avoidance.

Both intimacy and immediacy are "determined by verbal and nonverbal cues" and rely heavily on the extent to which the telecommunications medium itself can deliver such cues (Oh et al., 2018, p. 2). As such, intimacy and immediacy depend upon the sociability of the technological medium. Seminal theories in telecommunications, such as media richness theory (Daft & Lengel, 1986), argue that some technologies are inherently richer or superior in terms of their ability to deliver social cues. For example, synchronous video technologies are superior to voice telecommunications, which are superior to textual telecommunications. Therefore, the technological affordances of a medium can increase or decrease experiences of social presence for its users.

Walther (1992) rejects such a technologically-driven conceptualisation of social presence. Instead, Walther argues that people could adapt their social goals to various telecommunications media. In other words, the medium can be adapted to meet the user's needs by the user instead of the user's experience of social presence being wholly determined by the medium itself. Known as Social Information Processing Theory (SIPT), this perspective contends that social presence is more contingent on the interactants (users) than on the

mediating technology itself. Although, for example, text-based telecommunications tools may not afford the same kinds of verbal and nonverbal cues as richer mediums, the users' goals, behaviour, and experiences (interactants) can develop high levels of social presence, even if it takes more time to do so. In fact, Walther (1996) argues that some users of text-based computer-mediated communications tools could develop higher levels of social presence than face-to-face counterparts by intentionally choosing which aspects of themselves to reveal to their communications partners. Surely, this view was prescient of the social media revolution, with its selective sharing and carefully curated communications such as Tweets.

Both the technologically determined notions of intimacy and immediacy devised by Short et al. (1976) and the SIPT model proposed by Walther (1992) acknowledge that inherent differences in the technological media do make a difference in experiences of social presence. However, criticisms of technological determinism have been levelled at Short et al., and SIPT provides a more nuanced approach to understanding how users interact with technologies and one another to affect experiences of social presence. A holistic view of social presence should consider users' individual behaviours and the technological context of a telecommunications exchange (Oh et al., 2018, p. 3).

The literature overwhelmingly confirms that face-to-face interaction still yields the highest levels of social presence (Oh et al., 2018). For example, Juliann Cortese and Mihye Seo (2012) found that people using computer-media telecommunications tools felt lower levels of social presence than face-to-face communications. Comparable results concerning levels of social presence were found in online learning contexts (Zhan & Mei, 2013). An exception, however, was a study by Donata Francescato et al. (2006), which found that participants in an online seminar reported higher levels of satisfaction with their communication than their face-to-face counterparts.

2.2.1 Social Presence in Online Learning

The concept of social presence has been closely related to online teaching and learning theories. Kehrwald (2008) argues that research that supports the development of social presence theory could enhance online learning by exploring "learning designs which utilize social processes," promoting "social motivation" among online learners, improving the "social affordances" of telecommunications, and contributing to research related to "social cognition, interpersonal communication, and theories of mind" in online teaching and learning (p. 89). As a perceptual

construct, social presence is a "critical element of online learning environments" (p. 89). Öztok and Kehrwald (2016) later criticise the body of literature around social presence theory as "over extended and widely stretched" and that it has "long lost its depth and breadth, and thus, its analytical strength" (p. 259).

Since the early 2000s, there has been growth in the application of social presence theory to enhance the student experience in group situations in online learning (Kreijns et al., 2021). However, Gunawardena (1995) is recognised as the first researcher to apply the concept of social presence, and the underlying notions of intimacy and immediacy, to online and distance learning settings. In the context of a text-based, computer-mediated distance learning system known as "GlobalEd," Gunawardena was arguably the first to use social presence theory to explain student satisfaction in the online learning environment. Initially, Gunawardena defined social presence as "the degree to which a person is perceived as a 'real person' in mediated communication" (p. 151), which essentially corresponded to Short et al.'s (1976) original definition. Gunawardena expanded the definition beyond a psycho-social perception towards an interpersonal phenomenon in online and distance education that can be intentionally cultivated. Social presence is also a matter of how "social" users perceive a particular computer-mediated communication medium, not necessarily a function of the technological medium itself (p. 162). Gunawardena also associated social presence with social cohesion and a sense of community among students in online learning situations. Kreijns et al. (2014; 2021) would later identify this as the "sociability" subconstruct of social presence.

Early in the application of social presence theory to online learning, Kreijns, Kirschner and Jochems (2002) identified two "major pitfalls" which would impede "desired social interaction" in what they called at the time "computer-supported collaborative learning" (CSCL) namely, "taking interaction in groups for granted" and a failure to pay adequate attention to "the social psychological dimension of social interaction outside of the task context" in online learning (p. 8). By the former, they meant an assumption that group-oriented activities in online learning, such as threaded discussion forums, would not automatically foster social interaction. By the latter, they express the logical extension of the argument, i.e., group learning tasks, such as a required number of posts and replies to a threaded discussion forum are not enough to foster social interaction. Instead, there are social-psychological dimensions beyond prescribed tasks in the learning process.

Social presence has been associated with student-student and student-instructor interactions in online learning environments. Mykota (2017) identifies social presence as a "critical affective component" in online learning, an important construct to determine levels of interaction and "effectiveness of learning in an online environment" (p. 137). Poth (2018) argues that fostering social presence in online learning environments is "key to promoting a more engaging and supportive educational experience, in which students become more motivated" and can thus be more successful (p. 89). The number of courses taken in an online format (therefore, via computer-mediated communication) has been found to influence dimensions of the experience of social presence (Mykota, 2017). In addition, online learning courses tend to have diverse students from various backgrounds, providing opportunities for social interactions beyond their typical experiences (Warren, 2018). Therefore, patterns of interaction should be structured to maximise the experiences of social presence in online learning environments (Mykota, 2017). Chih-Hsiung Tu and Marina McIsaac (2002) found that the quantity of social interaction does not necessarily lead to positive outcomes related to social presence. Tu and McIsaac identify three dimensions of social presence, i.e., social context, online communication, and interactivity. Accordingly, their study found that social context, a highly subjective and qualitative factor, may influence perceptions of social presence more than frequent interaction alone. In fact, "it often takes time to develop social presence" (Kreijns et al., 2014, p. 12).

A study by Gary Bente (2008) found that users who experienced text-only telecommunication reported lower levels of social presence than users who experienced the same text-only telecommunication enhanced by audio-visual cues. Other studies have found that such audio-visual additions to text-only communications enhanced experiences of social presence (Sallnäs, 2005; Kim et al., 2014). While this study assumes a primarily text-based approach to online learning, there is no way to disaggregate the CERP survey data to parse out which computer science courses included, or excluded, audio-visual enhancements. As such, this study assumes a wide range of telecommunications media, tools, and modalities represented in the CERP survey data.

2.2.2 Counterarguments and Critiques

The literature contains counterarguments regarding social presence theory itself and its relevance to student experiences in online learning. For example, criticising the breadth but lack of depth in social presence research, Öztok and Kehrwald (2016) urge researchers to "focus more on the relative salience of interpersonal relationships" to understand better what

it means to experience social presence (p. 259). Öztok and Kehrwald go as far as to propose "killing" the whole idea of social presence because of the glut of research and lack of clarity around the theory.

Oh et al. (2018) note that while most studies affirm increasing social presence as a benefit in all telecommunications exchanges, such an assumption "misleads researchers to neglect the fact that social presence may not always yield positive outcomes" (p. 25). For example, subjective experiences of social presence might come down to individual preferences; for people who are shy or who do not prefer social interaction, over-emphasis on increasing social presence may yield negative outcomes. Moreover, the context of the telecommunications exchange also affects the extent to which social presence is beneficial. In some contexts, social presence may be detrimental to the purpose and context of the exchange. For example, the individual attitudes of communications partners, one to another, may also affect the positive or negative outcome of increased social presence. Thus, assumptions about social presence should be tempered, such as "attempting to increase social presence may not have uniformly positive results; rather, special attention should be paid to the communication preferences and goals of the interactants" (Oh et al., 2018, p. 25).

2.3 Conceptual Framework: Social Presence, Sociability, and Social Space

Conceptual and theoretical frameworks are interrelated but distinct (Grant & Osanloo, 2014). A conceptual framework, grounded in an underlying theoretical framework, provides epistemological and ontological specificity to constructs and definitions used throughout a research study (Luse, Mennecke & Townsend, 2012). Moreover, a conceptual framework is "an organizing structure or scaffold that integrates related ideas… other research, and theories to provide focus and direction" for a research study (Rallis, 2018, p. 355). Moreover, conceptual frameworks are used to proffer an argument and establish the significance of a research study (Rallis, 2018). Rallis (2018) notes that conceptual frameworks should ensure that prior research is "woven into the framework to ground the study in what is already known" and substantiate arguments, logic, and concepts (p. 355). Concepts are "essential components of theories" and abstracted labels assigned to "dimensions or elements of the real world" (Ngulube et al., 2015, p. 48). For this study, social presence theory writ large might be considered the overarching theoretical framework, and the specific subcontracts (social presence, sociability, and social space) the conceptual framework.

Therefore, the conceptual framework used for this study consists of the interrelated subconstructs proposed by Kreijns et al. (2021) to conceptualise social presence more precisely; these include social presence, sociability, and social space. In fact, Kreijns et al. explicitly admonish that "researchers concerned with social presence are encouraged to distinguish between the three major variables" which they identify in their proposed framework (p. 13). Applying this conceptual framework to the items on the CERP instrument around the problem of attrition in computer science education is the unique contribution of this study to the broader body of literature. The research design, instrumentation, data analysis, and interpretation of the results guide the conceptual framework.

2.3.1 Social Presence in Text-based Telecommunications

Nearly four decades have passed since Short et al. (1976) conceptualised social presence theory and, as Kehrwald (2008) acknowledges, despite nearly three decades of research since social presence was first associated with online learning environments, "a single, shared understanding of social presence has not emerged" (p. 89). Kreijns et al. (2021) exhaustively reviewed the literature surrounding social presence constructs over the past forty years and have attempted to develop a "coherent line of social presence research", investigating issues such as "interpersonal communication, group learning, and group dynamics" in the context of online learning (p. 139) by distilling and disentangling the varying definitions and measures grounded in social presence theory. Kreijns et al. (2021) argue that the notion of "salience" in computer-mediated communications identified by Short et al. (1976) as the basis for social presence theory "is ambiguous and non-operationalizable" because the very definition of "salience" remains elusive (p. 155).

Developing a conceptual framework from a theoretical framework should be "both inductive and deductive" (Rallis, 2018, p. 356). Derived from the overarching theoretical framework of social presence theory and the body of literature from which it is comprised, this study more precisely utilises a conceptual framework based on the three interrelated constructs identified by Kreijns et al. (2021), that is, social presence, social ability, and social space. Seeking to "disentangle" the theory of social presence as originally posited by Short et al. (1976), the conceptual framework devised by Kreijns et al. sought to accomplish three goals: firstly, to "reformulate" Short et al.'s social presence definition to advance "an operationalization in line with their conceptualization of social presence"; secondly, to depart from assumptions of

"technological determinism" related to social presence; and thirdly, to identify two other interrelated subconstructs, namely, "sociability and social space" (p. 141). The conceptual framework is summarised in Table 2.2 with justifications from Kreijns et al. (2021, p. 163).

Table 2.2 Conceptual Framework from the Social Presence Theory

Subconstruct	Justification
Sociability	"…the capacity of CMC tools and electronic platforms when it comes to giving expression to one's social presence and how one is perceiving or experiencing the other person's social presence to foster socio-emotional aspects of the learning experience" (p. 163).
Social space	"…the sense of community, group climate, mutual trust, social identity, and group cohesion" (p. 163).
Social presence	"…the unique psychological phenomenon that we perceive other social persons as being physical 'real' persons while using CMC tools and electronic platforms" (p. 163).

Sociability is linked to computer-mediated communication (CMC) tools, software, and hardware and represents the extent to which such tools foster an expression and experience of social presence through the "emergence of social space"; it is, therefore, a technological "medium attribute" (Kreijns et al., 2021, p. 141; Weidlich & Bastiaens, 2019; Kreijns et al., 2002). In early formulations of the notion of sociability, Kreijns et al. (2002) proposed embedding certain properties in online learning platforms to "act as social context facilitators" or, as they called them at the time, "social affordances," to sustain the social interactions of learners (p. 8). Platforms that foster "group awareness about others" in both the "task and non-task" contexts are technological embodiments of the original intentions of social presence theory (Kreijns et al., 2002). It should be noted that scholars, such as Gumbo (2020), have critiqued Western dominance in online learning technologies, calling for additional research into how "technology and its pedagogical and content delivery function by integrating indigenous knowledge to benefit students from non-western or indigenous cultural contexts" (p. 72). Sociability might provide a conceptual construct to critique and construct the cultural aspects of technological tools without devolving into technological or social determinism.

Social space "encapsulates group cohesion, mutual trust, and learning climate, aspects that have been consistently shown to be conducive to learning" (Kreijns et al., 2021, p. 159; Gunawardena, 1995; Williams, Duray, Reddy, 2006; Rourke and Anderson, 2002; Rovai, 2002). As in the phenomena of Internet-driven social network platforms (Katz et al., 2004), connections between socially networked individuals can be relatively strong or weak, but "all interpersonal relationships span a kind of space"; hence, Kreijns et al. (2021) "speak of a social space" (p. 159). Social space might be further defined as a "network of interpersonal relationships embedded in group structures of norms and values, rules and roles, and beliefs and ideals" (Kreijns et al., 2021, p. 159). In online learning environments, social space is "manifested by a sense of community, group climate, mutual trust, social identity, and group cohesion" (Kreijns et al., 2021, p. 159). When social space is sound in online learning environments, it yields productive social interactions that foster collaborative learning in a socially constructed space (Kreijns et al., 2021, p. 160). Collaborative learning is closely associated with social space because it involves more than one student engaging in the online learning process, creating a social situation (Kreijns et al., 2021; Johnson & Johnson, 2014).

Social presence, while based on the more seminal definition (Short et al., 1976), is "the unique psychological phenomenon that we perceive other social persons as being physically 'real' persons while using CMC tools and electronic platforms" (Kreijns et al., 2021, p. 163). It is both an overarching construct and a subconstruct. The other two subconstructs, social space, and sociability, "are closely linked with social presence yet separated from it" (Kreijns et al., 2021, p. 162). According to Kreijns et al. (2014), "social presence is a perceptual phenomenon rather than an ability" (p. 9).

Therefore, specific to this study, the conceptual framework, aligned to items on the CERP instrument, provides an overarching guide to data analysis and interpretation. A conceptual framework serves as a "catalyst that raises the researcher's thinking from the particular and descriptive to contribute to some larger body of ideas" contained in the research and theories of others (Rallis, 2018, p. 356). In conversation with other issues in the literature, namely, student attrition, persistence, satisfaction, and retention in online undergraduate computer science programmes, the conceptual framework facilitates the integration of the findings of this study with the broader body of literature in which it is grounded. While this study focuses on text-based communication, it is important to consider the potential of immersive technologies

such as Virtual Reality (VR) in enhancing social presence, a concept comprehensively defined and explored in the literature (Oh et al., 2018).

2.3.2 Social Presence in Immersive Technologies

Among varying degrees of sociability, so-called "immersive" technologies such as VR are recognised as having the most potential to enhance experiences of social presence. While this study is focused on text-based communications, it is important to consider the role of such immersive technologies in the broader literature. Oh, Bailenson and Welch (2018) systematically reviewed 233 separate findings from 152 studies to comprehensively define, measure, and predict "social presence" in telecommunications technologies. While early studies of social presence were limited to text-based computer-mediated communication, Oh et al. (2018) considered the implications of newer "immersive" technologies such as Virtual Reality (VR) devices. The authors' comprehensive study aimed to provide researchers with a framework on "how to maximize the amount of social presence one can feel within a given virtual environment" (p. 2). In so doing, Oh et al. (2018) proffer "immersion and presence" as "two key concepts" as well as "telepresence and self-presence" as two "separate dimensions" of social presence (p. 2). Together, these four components provide a basis for exploring what "does (and does not) impact perceptions of social presence" (p. 2).

According to Oh et al. (2018), the terms "immersion" and "presence" must be distinguished in terms of "technological qualities" versus "psychological experiences" (p. 2). Drawing on a study by Slater and Wilbur (1997), Oh et al. define immersion as "a medium's technological capacity to generate realistic experiences that can remove people from their physical reality" (p. 2). In this way, immersion is a measure of the technological medium itself, not unlike Kreijn et al.'s (2021) concept of "sociability." Technologies are more or less immersive, depending on the extent to which they include audio, visual, and even haptic feedback for the user.

On the other hand, presence is the "subjective experience of actually being in" a technologically mediated environment (Oh et al., 2018, p. 2; Slater & Wilber, 1997). This concept of "presence" has been studied by researchers of virtual reality experiences (Cummings et al., 2012). Oh et al. then divided their definition of "presence" into three subcategories which cover "telepresence (spatial presence)," "self-presence," and "social presence," following an earlier study by Kwam Min Lee and Clifford Nass (2004).

Oh et al. define "telepresence" according to an earlier definition as "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment" (in Steuer, 1992, p. 75). In other words, telepresence is how subjectively vivid the mediated experience is to the user. Users in mediated environments with strong telepresence perceive less of the technological mediation of the telecommunications medium. Similarly, "self-presence" is the extent to which users perceive their mediated (or virtual) selves as indistinct from their "real" selves. Oh et al. (2018) use the definition by Aymerich-Franch, Karutz and Bailenson (2012) for "self-presence", i.e., the measure of how much the "virtual self is experienced as the actual self" (p. 1). Users may also feel a connection to their virtual selves, and the measure of that connection is also a form of self-presence (Ratan & Hasler, 2009).

Finally, Oh et al. (2018) nuance a description of social presence using the definition by Biocca, Harms and Burgoon (2003), namely, a "sense of being with one another" (p. 456). Accordingly, social presence defined this way depends on "access to the intelligence, intentions, and sensory impressions of another" (Biocca, 1997, p. 22). Oh et al. point out that social presence versus telepresence and self-presence in virtual reality environments are "co-present entities that appear to be sentient" (p. 2). Social presence is critically important for environments that mediate the communications of real people – not virtual entities or artificial intelligence agents – because without the experience of social presence, "the mediated other is merely experienced as an artificial entity and not a social being" (p. 2).

2.3.3 Immersive Qualities, Contextual Properties, and Individual Traits

While most research on social presence theory in online learning has focused on text-based CMC, immersive technologies, such as VR, have also become a subject of study. In a comprehensive review of prior research, Oh et al. (2018) also propose three predictors of social presence: immersive qualities, contextual properties, and individual traits (p. 10). General modalities (text-based, audio-visual, virtual reality) are considered the primary way of measuring the immersive qualities of a telecommunications medium (Oh et al., 2018, p. 19). While there are some fundamental similarities between text-based CMC, audio-visually rich CMC, and emerging VR technologies, there are also unique properties and considerations among various telecommunication modalities.

According to Oh et al., contextual properties are the extent to which social psychological and interpersonal dynamics can be replicated in the computer-media environment. Accordingly,

contextual properties are “psychological processes that allow individuals to interpret the available social cues in more positive (or negative) ways” (Oh et al., 2018, p. 23). Contextual properties include agency, task type, social cues about the presence of others, and identity cues. Agency refers to the extent to which a computer-mediated interaction feels like an interaction with a real human agent versus an artificial intelligence bot or simulated avatar. Unsurprisingly, users who believed they were interacting with a real human agent reported higher levels of social presence. As the term suggests, physical proximity is the actual physical distance (or closeness) of the two agents in a telecommunications exchange. Unsurprisingly, people who knew they were in close physical proximity or even co-location expressed higher levels of social presence. Task type, the extent to which a given task in a computer-mediated environment requires attention to and accommodation of human behaviour, also influences experiences of social presence. When tasks expect more attention, experiences of social presence are enhanced. Social cues about the presence of others, or people knowing explicitly that they participate in a social telecommunications exchange, also enhance social presence. Finally, psychological traits suggest that people with positive psychological predispositions towards social interactions will report higher experiences of social presence, regardless of the medium. In other words, people who are “less socially-oriented may lack the ability to adequately attend to social information at hand” (Oh et al., 2018, p. 23).

The meta-analysis by Oh et al. (2018) highlights the debate surrounding the role of technology versus human agency among researchers of social presence theory. Even within the context of so-called “immersive” technology such as Virtual Reality, the role of technology and its effects on subjective human experiences remain debatable. No definitive theory of social presence in telecommunications has yet emerged, but research continues to refine and nuance definitions, constructs, and measurements.

2.4 Sociological Theories Relevant to the Social Presence Theory

This section reviews various classical sociological theories, considering social presence theory’s theoretical and conceptual frameworks. Relevant comparisons and contrasts are drawn according to the existing literature and set in a broader theoretical context within the discipline of sociology. Symbolic interactionism, Erving Goffman’s (1922; 1982) “dramaturgy,” social situationism, and social constructionism are examined for relevance to social presence theory. Such sociological theories are important to the theoretical framework surrounding social

presence because there is continued debate concerning "the question of whether social presence is determined by technological attributes of the communication media or is determined by the social group using those media" (Kreijns et al., 2014, p. 8).

2.4.1 Symbolic Interactionism

Symbolic interaction is one of the three major theoretical schools in contemporary sociology. The fundamental notion of symbolic interactionism theory is that all human actions and interactions depend upon socially constructed symbols of communication (that is, their origin in society itself). Human beings are actors, or agents, who ascribe meaning to socially relevant symbols and use them for purposes of communication and interactive exchange. Meaning, therefore, arises from social interaction. Symbolic interactionism is relevant to the social presence theory because it attempts to describe how one-on-one interpersonal interactions occur and how meaning arises from them, and how collective interpersonal actions give rise to social meaning in many-to-many interactions. Symbolic interactionism is a more humanistic approach to understanding human social behaviours, contrasting with earlier behaviourists such as B.F. Skinner and Pavlov. Human beings behave not only according to mere stimulus-response mechanics because they are not wholly determined by their environment but by human agency itself. Epistemologically speaking, there is no single, objectively knowable reality, but only situational interpretations of experiences (Charmaz, Harris & Irvine, 2019).

Charles Horton Cooley (1864-1929) proposed the notion of the "Looking Glass Self," which describes how human beings understand themselves in a social context: that is, a "reflected appraisal," or an interpretation of how human beings think about themselves. For Cooley, the self is developed through the lens of the perceived judgment of others. George Herbert Mead (1863-1931) focused on the phenomenon of self-actualisation. By interacting with others, one's self-perception is shaped and actualised. Contemporary applications of Mead's theories of self-actualisation continue to influence sociological research in various contexts (McVeigh, 2020). Symbolic interactionism is relevant to theories of social presence because its philosophical and sociological proposals predate CMC and provide foundational language for understanding human interaction. Because social presence theory seeks to describe, measure, and understand perceptions between interlocuters of CMC across various media, symbolic interactionism can provide a broader sociological context to how human beings ascribe meaning to the symbols they exchange. Symbolic interactionism has been applied to understanding how users of

various Internet-based technologies, such as social media, create and ascribe meaning to shared communication symbols (Chen, Davison & Ou, 2020).

Contemporarily, Bruno Latour (1947-2022) elevated symbolic interactionism into the twenty-first century and advanced the social constructionist school of sociological thought but diverged by rejecting a strict subjective-objective paradigm for understanding reality. Instead, Latour proffered an Actor-Network Theory (ANT), especially appropriate for telecommunications, which was influenced by a lesser-known rival to the father of sociology Émile Durkheim, Gabriel Tarde, and methodological influences from Harold Garfinkel, such as the idea of generative semiotics from Aldigras Julien Greimas.

Latour rejected subject-object distinctions as typically fashionable in postmodern circles. But, in *We Have Never Been Modern* or *Nous n'avons jamais été modernes* (1991), Latour instead offered a "nonmodern" or "amodern" perspective to reconcile the apparent divide between science and technology on one hand and social reality on the other. Latour continued to explore provocative ideas regarding science and society in other books and articles, such as *Science in Action* (1988) and *Pandora's Hope* (1999). Latour's final book, *Reassembling the Social* (2005), attempted to bring science and sociology into conversation with metaphysics and ontology. Like traditional symbolic interactionists, Latour suggested that society, or "the social," does not exist objectively. Therefore, researchers should not attempt to straightjacket human behaviour into social frameworks as if they exist objectively. Instead, for Latour, "the social" is constructed and brought into being as the actors, human agents, experience them. Latour's relativism, brought to its logical end, has been criticised as unrealistic (Sokal, 2010). Nils Oliver Klowait (2019) follows Latour in arguing that "as communication technology advances, the importance of mediated interaction grows, prompting attempts to update interactionism for non-face-to-face interactions such as teleconferencing, social networks, and virtual reality" (p. 605).

2.4.2 Goffman's Dramaturgy

Erving Goffman (1922-1982) proposed a sociological theory that all interpersonal interaction is performative and that people present themselves to one another in certain ways to achieve specific goals. For example, within interpersonal communication, people continuously engage in "impression management" to control how others see them and enhance their self-image. In addition, individuals maintain "face" by engaging in "face work," through which they ascribe

levels of social value to themselves through interpersonal interactions. Goffman highlighted his theory of social interaction in his book *The Presentation of Self in Everyday Life* (1959). Goffman used the term "dramaturgy" to elicit the notion of performance. People present themselves differently in different social situations. In public settings, Goffman argued, people create a "front stage face," and in private settings, people create a "back stage face" and carefully manage their performances between the two. The face people present to others depends on whether an interpersonal exchange occurs in the front or backstage. The goal of presenting difference faces, or performing differently on different stages, is to maintain a positive self and social image (Goffman, 1959).

Goffman's dramaturgy theory of how people present themselves in social interactions is relevant to social presence theory in online learning environments. Liam Bullingham and Ana Vasconcelos (2013) apply Goffman's theory to study the formation of online identities. Bullingham and Vascanecelos note that online interactions provide specific "potential for editing the self" and have implications for understanding how people interact online (p. 101). Goffman's notion of "copresence" has been specifically used as a theoretical grounding for exploring social presence theory (Biocca et al., 2003). In fact, Shanyang Zhao and David Elesh (2008) argue that copresence is social in nature while colocation is physical in nature. Copresence does not necessitate colocation and can be achieved in online environments. However, despite the "ubiquitous connectivity" afforded by the Internet, Zhao and Elesh conclude that "so long as there are social barriers that separate people into different groups of interests and different positions in the hierarchy of fame and power, there will be fragmentations in the online world that make the ubiquity of social connectivity impossible" (p. 565).

Goffman's theory is relevant to the study of social presence because it informs how people present themselves in social situations. When using Computer Mediated Communications (CMC) tools, online learning environments, particularly social selves, are presented and perceived through each medium. Social identities, especially the notion of copresence, in online learning environments, are part of understanding social presence as a construct (Bullingham & Vascancelos, 2020; Zhao & Elesh, 2008). How social selves are presented and perceived through CMC tools is a manifestation of social presence, and Goffman's theory provides insight into this process. However, it is also important to consider the influence of situational

factors on human behavior, which is the focus of social situationism, a theoretical perspective in sociology.

2.4.3 Social Situationism

Social situationism is a theoretical perspective in sociology (specifically, symbolic interactionism) that emphasises the influence of the immediate social context, the "situation," in human behaviour. According to this perspective, situational factors, such as social norms, group expectations, and interpersonal cues in a given social situation, affect how people act and behave. Social situationists argue that traditional individual intrapsychic processes do not adequately account for the context-dependent nature of human behaviour. When studying social phenomena, situational factors that influence behaviour must be considered. For the purposes of this study, social situationism may help clarify experiences of social presence in the online learning "situation."

The "Thomas Theorem," or the "Thomas Dictum," is a sociological concept rooted in social situationism formulated by William I. Thomas (1863-1967) and Dorothy Swaine Thomas (1899-1977) in their book, *The Child in America: Behavior Problems and Programs* (1928; 1970). The Thomas Theorem is often expressed as the axiom: "if people define situations as real, they are real in their consequences." In other words, human behaviour is influenced strongly by subjective interpretations of social reality, regardless of whether such interpretations are objectively verifiable. Situationists apply the Thomas Theorem to explain how subjective interpretations of reality shape social interactions and how perceptions of social experiences affect individual and interpersonal behaviours.

The Thomas Theorem is often expressed as the "definition of the situation" and is rooted in symbolic interactionism because it is a formulation of socially-constructed reality. When social actors or groups define situations as "real," they engage in what Thomas Merton called a self-fulfilling prophecy, or in more pragmatic terms, "groupthink" (Chandler & Munday, 2011). People behave according to what they perceive.

Both social situationism and the Thomas Theorem are relevant to social presence theory because they provide additional theoretical structure for understanding how reality is socially constructed in specific situations. Given that interaction in online learning is a social situation, it follows that learners subjectively define a situation as real (socially constructed reality

together in the online environment), and consequential behaviours will ensue regardless of the objectivity of that definition. Because the most fundamental aspects of social presence theory deal with the extent to which others are "perceived as real" in a telecommunications exchange, subjective perception and its influence on behaviour are central to understanding the phenomenon.

2.5 Social Constructionism and Related Theories of Learning

This section examines social constructionism and its antecedent, constructivism, considering seminal and contemporary literature. There is persistent confusion in the academic literature concerning differences and distinctions between social constructionism and social constructivism. As a result, nuanced definitions exist, but the terms are sometimes used interchangeably. For example, the open-source Learning Management System "Moodle" has been described by its developers and users as based on constructionism and constructivism theories (Moodle, 2018; Forment, 2011; Wood, 2010).

According to a proposal by Rob and Rob (2018):

> A constructivist teacher sets up the learning environment for students that fosters individual learning and presents a problem to be solved, while the students go on their own way to produce a personally meaningful artifact without any further teacher's intervention. On the other hand, the constructionist teacher sets up the environment for collaborative learning for students, then he or she defines the problem to be solved and the meaningful end product to be developed, and then guides them to reach towards the goal (p. 289).

Moreover, Rob and Rob (2018) suggest that "understanding the critical differences" between social constructionism and social constructivism learning theories is important to educators at all levels, from the education of children in primary grades to the education of adults at the university level (p. 298). In their study, Rob and Rob implanted their framework in two Information Technology (IT) courses and solicited student feedback regarding its efficacy.

Jean Piaget's social constructivism and Seymour Papert's later constructivism are explored in the subsections below, considering each theory's prevailing similarities and differences. Both

are relevant to understanding social presence theory in online learning because they seek to explain how people learn in social contexts and, in Papert's case, how people use technological tools to construct knowledge.

2.5.1 Piaget's Social Constructivism

Piaget (1896-1980) was a Swiss-born developmental psychologist and epistemologist who proposed a "constructivist theory of knowing" in his classic book *The Construction of Reality in the Child* (1954). Piaget's theories have been compared and contrasted with Lev Vygotsky's idea that social learning precedes cognitive development. Vygotsky argued that learning is taught through society and social structures, while Piaget argued that learning is socially constructed through interpersonal interaction and experiences (Pass, 2004).

Piaget's theory of social constructivism suggests that people "construct" their understanding of the world through social experiences and interactions with others. Piaget was a developmental psychologist, so much of his theory deals with how children learn. He proposed a series of stages through which children progress as they socially construct knowledge. Piaget's stages included a sensorimotor stage (birth-2 years old), a preoperational stage (2-7 years old), a concrete operational stage (7-12 years old), and a formal operational stage (12-adulthood). The final stage is where people formulate hypothetical and logical reasoning and can grapple with abstract concepts (Piaget, 1954).

Piaget argued that educators should provide children with opportunities for independent exploration, collaborative problem-solving, and learning through experience. Often, educators adapt Piaget's theory to focus more on a facilitative approach to teaching which guides students toward constructing their own knowledge through experiences. From Piaget's view, constructivism is about how knowledge is cognitively constructed. At the same time, Seymour Papert's social constructionism focuses more on the tools, especially technology, that can be used in constructing such knowledge (Ackerman, 2001). Papert's social constructionism can be viewed as an extension of Piaget's constructivism, with a focus on the role of technology in constructing knowledge. Piaget's theories have been applied to the online learning context (Misman, Jaini, Kaidr, Mahmood, Rashid, & Dzulkifli, 2021).

2.5.2 Papert's Constructionism

Seymour Papert (1928-2016) was a South-African-born educational theorist, mathematician, and computer scientist who spent most of his academic career at the Massachusetts Institute of Technology (MIT) in the United States. Early in the personal computer revolution, Papert advocated for children to have access to computers and to learn computer programming through hands-on experiences. Papert invented the LOGO programming language, widely used in schools in the 1980s to introduce children to computing. As an educational theorist and student of Piaget, Papert is best known for expanding on Piaget's cognitive development theories to propose social constructivism. Papert's ideals were expressed in books such as *Mindstorms: Children, Computers, and Powerful Ideas* (1980) and *The Children's Machine: Rethinking School in the Age of Computer* (1994), as well as through outreach projects such as Lego Mindstorms, which used the popular building blocks toys to teach the fundamentals of robotics and programming.

Papert's theory of constructionism emphasised the role of the social context in which learning occurs. Learning is "constructed" through interaction with others and with the environment. Papert believed that technology, especially the computer, is a tool to support and enhance the process of knowledge construction, allowing learners to explore and experiment with ideas in an open-ended way. Papert also argued that learning should be student-centred: students should be encouraged to direct their learning and construct their knowledge using technology, tools, and hands-on exploratory experiences (1991, p. 3).

Papert used various examples from his own career as an educator to promote socially constructed learning experiences, such as building things out of Lego or soap, and extended those examples to technological applications. Papert acknowledged that he did not believe that "anyone fully understands what gives" experiential learning activities "their quality of 'learning richness'" but argued that such a lack of understanding should not prevent educators from "taking them as models in benefiting from the presence of new technologies to expand the scope of activities with that quality" (1991, p. 9). Papert did not imply that socially constructed learning should be entirely without "instructions." Still, that freedom to create with tools, especially technological and computing tools, is critical to his theory of constructionism (1991, p. 10).

The potential of constructionism is amplified when learning occurs collaboratively in groups, and students can learn and construct knowledge together. Accordingly, Papert has been credited with inspiring contemporary educational movements such as both Problem-Based and Project-Based Learning (PBL) and other collaboratively-oriented approaches to teaching and learning (Barak, 2020). Papert's constructionism has also been cited in recent applications of PBL through teaching mathematical and computational thinking using computer science education tools such as Scratch (Hadi, Atiqoh & Kadir, 2020; Voinohovska, Tsankov & Goranova, 2019; Carbonaro, Rex & Chambers, 2004). While constructionism emphasises hands-on experiences and collaborative learning, the Community of Inquiry (CoI) framework exemplifies how constructivist ideas can be adapted to facilitate online learning communities.

2.6 Community of Inquiry Framework

The Community of Inquiry (CoI) is a widely used theoretical framework for designing and facilitating collaborative learning in online environments related to social presence theory. In CoI, "community" refers to "a group of individuals with common expectations and interests" (González Miy & Herrera Díaz, 2015, para. 5), and "inquiry" refers to John Dewey's (1980; 1938) pragmatic approach to critical thinking. Exemplifying the constructivist paradigm, online learning communities "comprise a participative network that stimulates communication, the contribution of ideas, and socialization of experiences that lead to personal and collective identity, and as a result, builds knowledge" (González Miy & Herrera Díaz, 2015, para. 9). The CoI framework is an attempt to adapt such communities to online learning (Tolu & Evans, 2012).

First proposed by Randy Garrison, Terry Anderson and Walter Archer (1999) at the University of Alberta in Edmonton, Canada, the framework is based on constructivist theory. The framework is based on three interdependent elements: social presence, cognitive presence, and teaching presence. Garrison et al. (1999) acknowledge that a shift in higher education was occurring through the rise of online learning and the use of CMC from primarily spoken (oral) interaction to primarily text-based (written) interaction in the teaching-learning dynamic. Online learning platforms, especially in the earliest days of the Internet, were by necessity and, therefore, by design, almost entirely "text-based." In fact, Archer, Garrison and Anderson had previously addressed this shift before conceptualising their CoI framework, and they describe such text-based interaction as "computer-based conferencing."

For Garrison et al. (1999, p. 6), text-based interaction is a "lean medium" because it screens "out much non-verbal and paralinguistic communication," which may detract from the "quality of learning". However, Garrison et al. defend an important advantage to a primarily text-based modality for online learning: time for reflection and critical thinking supported by the process of writing. Unlike synchronous oral exchanges, asynchronous text-based exchanges allow learners (and instructors) to think deeply and critically before communicating, plan and formulate their thoughts, and refine their arguments. At the time of their seminal article, Garrison et al. (1999) acknowledged that there was limited "empirical evidence to suggest that text-based communication used in computer conferencing can, in fact, support and encourage the development and practice of higher-order thinking skills" (p. 7).

The CoI framework fosters the process of "the individual constructing meaning collaboratively confirming understanding through critical thinking and discourse" (Garrison, 2012, p. 5). To bridge the gap between the communications medium and the kinds of higher-order thinking skills they hope to foster, Garrison et al. (1999) turned to the notions of community, social context, and collaboration. The CMC environments allow groups to interact and, therefore, can create social experiences. The CoI framework has been expressed in terms of three phases: "(1) acquiring a social identity, (2) having purposeful communication, and (3) building relationships" (Kreijns et al., 2014, p. 5). Shea and Bidjerano (2010; 2012) extended the CoI framework with a fourth presence, learning presence.

The CoI framework has been expressed as a Venn diagram with overlapping circles representing each of the three presences (Figure 2.1). Where social presence and cognitive presence overlap, discourse is supported. Where social presence and teaching presence overlap, the community climate is set. Where cognitive presence and teaching presence overlap, content is selected. Where all three presences overlap, the overall educational experiences for the learner are created. Finally, the Venn diagram illustrates the fact that the entire CoI framework is set in the context of the communication medium. In the case of online learning, the CoI framework has typically been applied to a text-based communications medium, much like most of the research surrounding social presence theory in general.

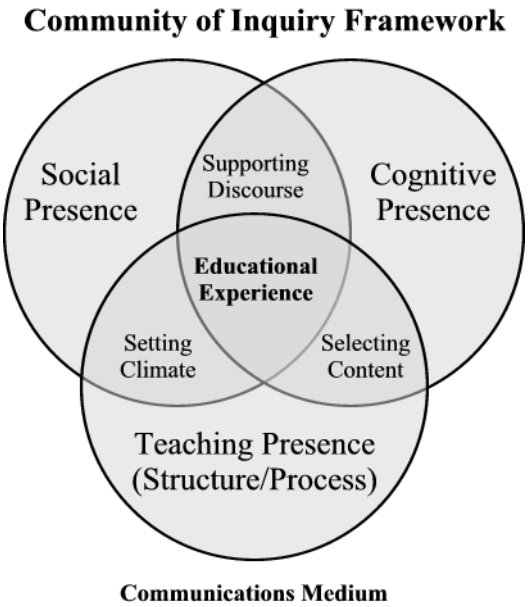

Figure 2.1: Community of Inquiry Framework

2.6.1 Social Presence in CoI

Garrison et al. define social presence differently from the rudimentary definition of "realness" or "salience." Instead, social presence is defined as the extent to which participants "identify with the community, communicate purposefully in a trusting environment, and develop interpersonal relationships by way of projecting their individual personalities" (Akyol, 2013, p. 44). As such, this definition is closer to Kreijns et al.'s (2021) notion of "social space." Social presence is the first of the three components of the CoI framework and is, in sum, the extent to which learners can connect on a personal level in an online learning environment.

Critics have argued that the role of social presence, as defined in the CoI framework, is exaggerated (Annand, 2011). Kreijns et al. (2014) argues that the CoI conceptualisation of social presence should be disambiguated from more general conceptualisations of social presence, especially more settled definitions like "realness" and "salience." Instead, in the CoI context, social presence should be explicitly referred to as "CoI social presence" (Kreijns et al., 2014, p. 16). In contrast with the conventional understanding of social presence in telecommunications, the CoI framework focuses on "collaborative groups with possibly more than two members" (Kreijns et al., 2014, p. 15). In addition, social presence is concerned about perceptions of one-to-one communications, whereas CoI is concerned about many-to-many communications.

2.6.2 Cognitive Presence in CoI

In the CoI framework, cognitive presence is the extent to which learners can construct and confirm knowledge through individual critical reflection and collaborative discourse. Garrison et al. have appropriated Phases of cognitive presence, and various approaches to analysing the phases of cognitive presence have been applied to the online learning context. Cognitive presence has four phases: triggering event, exploration, integration, and resolution. The first phase of cognitive presence is a "triggering event" characterised by a thought-provoking question to instigate critical thinking or dialogue among learners. The second phase, exploration, occurs as the learner actively engages with the triggering event. Typically, in the context of a discussion forum, learners share their perspectives and experiences and formulate a shared understanding of the triggering event. Brainstorming and sharing ideas and resources are typical during the exploration phase. The third phase of cognitive presence integrates shared knowledge with each learner's experience and existing knowledge. Synthesis, connections, and application of concepts to new situations occur during the integration phase. Integration involves critical thinking, evaluation, and reflection. Finally, resolution involves a conclusion, or in collaborative terms, reaching a consensus or resolving conflicting views. The resolution phase is perhaps the most indicative of social learning and social constructivist theories and exemplifies the construction of knowledge by a community of learners (Garrison et al., 1999).

Neto, Rolim, Pinheiro, Lins, Gašević and Ferreira Mello (2021) devised a machine-learning approach to automatically analyse online discussion messages to classify cognitive presence. Intended to analyse text in the Portuguese language, the study concluded that particular features are relevant to predict cognitive presence in the educational context, namely, datasets relevant specifically to the subject matter of the discussion topics. The model attempted to classify the four phases of cognitive presence but found that the nuance of academic subject matter (biology, in this case) made it difficult to distinguish between the exploration and integration phases.

2.6.3 Teaching Presence in CoI

Teaching presence is "the design, facilitation, and direction of cognitive and social processes for the purpose of realising personally meaningful and educationally worthwhile learning outcomes" (Anderson, Rourke, Garrison & Archer, 2001, p. 5). Anderson et al. (2001) argue that the function of teaching does not necessarily change, but "certainly its manifestation looks quite different" in a computer-mediated context (p. 14).

According to Zehra Akyol (2013), teaching presence is “the design, facilitation, and direction of cognitive and social processes” to realise “personally meaningful and educationally worthwhile learning outcomes” (p. 44). Furthermore, teaching presence bridges social presence and cognitive presence by encouraging individual expression and building community in the online learning environment. Therefore, teaching presence can be understood as a synthesis of social presence and cognitive presence in this context (Anderson et al., 2001, p. 5). Bandura’s social learning theory, which emphasises the importance of social interaction in shaping individual behaviour, serves as a theoretical foundation for collaborative learning.

2.7 Collaborative Learning and Ubuntu

Albert Bandura (1925-2021) proposed a social learning theory (1969, 1976, 1977) according to which human beings learn through observation. By observing others in the social context, people learn by evaluating the consequences of actions and adapting their own behaviour accordingly. People can adjust their behaviour through self-regulation and self-reflection. Not unlike earlier theories of operant conditioning, Bandura emphasised the importance of reinforcement in learning. In sum, social interaction shapes individual behaviour. Collaborative learning is, therefore, a contemporary practice based on Bandura’s social learning theory. Collaborative learning is an approach to teaching and learning that emphasises group work, cooperation, and peer support in achieving shared goals. Collaborative learning theory assumes that students learn better when they engage in social learning rather than individual learning. According to Laal and Ghodsi (2012), collaborative learning, “compared with competitive and individualistic efforts, has numerous benefits and typically results in higher achievement and greater productivity, more caring, supportive, and committed relationships; and greater psychological health, social competence, and self-esteem” (p. 489). Collaborative learning can also help students develop a sense of community and belonging (Stoytcheva, 2021).

In the online learning context, collaborative learning can occur through various online learning tools and activities, not just threaded discussion forums. For example, interaction with blogs, chats, wikis, and case study discussions can facilitate collaborative learning in the online environment (Boton & Gregory, 2015). In collaborative learning, students work together in small groups to solve problems, complete tasks, or achieve learning objectives, often with instructor guidance. Connectivism is a contemporary learning theory that emphasises the

importance of technology and social networks in shaping learning. In online learning contexts, collaborative learning can occur through various online learning tools and activities, not just threaded discussion forums. Despite concerns raised by critics and scholars such as Sherry Turkle (1948-present), social media and social networking platforms have become ubiquitous in modern society, and educators are increasingly exploring their potential to enhance student learning and engagement.

The African notion of Ubuntu is a philosophy that emphasises the interconnectedness of human beings and the importance of community in shaping individual identity and behaviour (Oliver, 2021). Ubuntu shares similarities with social presence theory in that it recognises the importance of interpersonal relationships in shaping social interactions and fostering a sense of belonging (Makoe & Shandu-Phetla, 2019). The Ubuntu philosophy is fundamentally compatible with the CoI framework and collaborative learning. The CoI framework suggests that learning is most effective when individuals construct knowledge and meaning together through sustained reflection and discourse. Ubuntu emphasises the importance of collaborating to achieve common goals and solve problems, recognising that individual success often depends on the support and contributions of the broader community. Regarding Ubuntu, collaborative online learning may involve creating peer support to facilitate social interaction and foster a sense of community among students (Gunawardena, 2020).

Ubuntu also emphasises the importance of empathy and respect for others, which are compatible with social presence and the CoI framework. Empathy involves recognising and responding to the emotional needs of others, while respect involves valuing the perspectives and contributions of others. Empathy and respect foster a sense of social space in the context of collaborative learning. Ubuntu can be expressed in a supportive and inclusive online learning environment that encourages students to share their ideas and perspectives without fear of judgment or criticism. Ubuntu provides another undergirding philosophy for creating supportive and inclusive online learning environments emphasising community, collaboration, empathy, and respect (Gunawardena, 2020).

2.8 Connectivism

Related to social learning and collaborative learning theories, connectivism is a learning theory that emphasises the role of technology and social networks in shaping learning. According to

George Seimens' (2005) seminal article on connectivism, learning includes not only the acquisition and creation of knowledge but also establishing and maintaining connections with people, resources, and ideas. Connectivism assumes that knowledge is distributed across networks, and learning involves navigating such networks to access and make sense of information. Such skills are especially important in a globally connected world, where information abounds but is in constant flux. Connectivism argues that students must be able to evaluate and adapt to changing information (Utecht & Keller, 2019).

An important feature of connectivism is its notion that learning occurs through networks (Downes, 2022). Like Bandura's social learning theory, connectivism assumes a certain socialisation through technology (Melrose & Perry, 2014). Connectivism has been related to the Community of Inquiry (CoI) framework in online learning contexts (Cleary, 2020). By integrating connectivist principles with the CoI framework in an online learning programme, Yvonne Cleary (2020) identified two interventions to facilitate student connections: a "face-to-face" orientation at the beginning of an online course or programme and a peer-review activity. The latter was particularly effective in a graduate-level course.

Critics of connectivism question whether interdependence detracts from developing students' abilities to learn independently (Kop, 2011). João Mattar (2018) argues that connectivism is merely a technological extension of social constructionism. Connectivism also emphasises the role of social media in shaping learning. Social networks enable people to share information, collaborate, and socially construct knowledge. Educators who embrace connectivism argue that students must develop digital literacies to navigate social networks throughout the learning process (Downes, 2019). Víctor Pando (2018) argues that because of connectivism's inherent reliance on technology, it can dehumanise the learning process and, in turn, the learners as well. Critics suggest that connectivism is rooted in an over-reliance on technology that can lead to a lack of independent learning and critical thinking skills among students.

2.9 Social Networking and Social Media

Since the emergence of "Web 2.0" in the late 2000s, social media has provided a means for people to connect, communicate, and share on common platforms. Although there is no common definition of "social media" versus any other online telecommunications platform, social media generally involves user-generated content shared with an online community of

voluntary connections or followers (Aichner, Grünfelder, Maurer & Jegeni, 2021). Social networking, the notion of establishing formal social connections using common platforms, has been replaced by the phrase "social media" due to the acceleration of sharing text-based communications, images, and video content (Sledgianowski & Kulviwat, 2009).

Sherry Turkle (1948-present), a social scientist at Massachusetts Institute of Technology (MIT), is considered a foremost scholar on the effects of social media technologies on society and human relationships. Turkle's best-known books include *The Second Self: Computers and the Human Spirit* (1984; 2005), *Alone Together: Why We Expect More from Technology and Less from Each Other* (2012), and *Reclaiming Conversation: The Power of Talk in a Digital Age* (2016). Turkle's work has shaped public discourse around technology, especially social media, and its impact on society. Turkle argues that the proliferation of social media has led to a "culture of distraction" because people constantly connected to such platforms lose touch with their "real" social relationships outside of the online environment. Accordingly, social media creates a false sense of intimacy and connection, leading people to believe they have meaningful relationships with others when social media relationships are artificial and shallow. Furthermore, not unlike Goffman's dramaturgical theory, Turkle (2005) argues that social media platforms encourage people to present a "curated" version of themselves online, exacerbating feelings of inadequacy and insecurity when they see curated versions of others online. Finally, Turkle believes that social media can contribute to a lack of empathy due to decreased face-to-face communication, harming social and emotional well-being.

However, Turkle (2016) also believes that social media platforms have inherent benefits to society, such as allowing people to connect with others who share similar interests and providing a platform for marginalised voices to be heard. Moreover, social media platforms have provided unprecedented means for sharing content, expressing personal ideas, and networking with others. For Turkle, social media is a complex and multifaceted phenomenon that can positively and negatively affect human relationships. Therefore, social media and related technologies must be examined critically and with nuance. Turkle (2015) applied some of her ideas to the challenges of teaching in an "age of distraction" where the ubiquity of social media competes with course content, discussions, and interaction for students' attention.

In a study of social presence and social interaction theories in social media, Jahng and Littau (2015) found that audiences rated journalists more interactive on social media platforms as

more credible. Turkle (2012), however, warns that the "networked life" of social media is a world where people can "hide from each other, even as [they] are tethered to each other" (p. 1). Social media platforms create unique opportunities for studying social presence theory in an ever-connected world. As online learning programmes continue to expand, "overall issues related to the sociology of learning must be addressed," including "the nature of online interaction and collaboration and the role of social media" (Cohon & Hambrusch, 2018, p. 134).

Although social networking and social media are not directly related to online learning, their ubiquity demands consideration, especially considering social presence theory. Early in the rise of social media, Patrick Lowenthal (2011) distinguished between course-bound and unbound communication tools in online learning, naming traditional discussion forums as course-bound and social media platforms as course-unbound. Lowenthal argued that "researchers and practitioners alike will have to consider a new host of things related to social presence with the continued blurring of boundaries" (p. 128) between communications within bound learning management systems and communications on external social media platforms.

2.10 Synthesis of Theories and Relevance to the Study

The social presence theory is the primary theoretical framework guiding this study, which is the degree to which individuals communicating through technological media are perceived as real persons by one another. The social presence theory has traditionally focused on CMC technologies, but in recent decades, it has been closely associated with online learning, particularly group learning in online environments (Kreijns et al., 2021). Social presence is relevant to social constructionism and "computer-supported collaborative learning environments" (CSCLEs) in both synchronous and asynchronous online learning (Kreijns, Kirschner & Jochems, 2003, p. 335). A holistic view of social presence should consider user behaviour and a telecommunications exchange's technological context (Oh et al., 2018, p. 3). The literature review in this chapter can be synthesised according to nine broad categories, each directly related to the conceptual framework's three subconstructs: social presence, sociability, and social space.

Firstly, classical sociological theories relate to social presence theory in terms of a perception of the realness of others in technologically mediated communication. Symbolic interactionism

emphasises that human actions and interactions rely on socially constructed communication symbols. Symbolic interactionism may provide theoretical rigour to social presence regarding how users of various Internet-based technologies, such as social media, create and ascribe meaning to the communication symbols they exchange. Symbolic interactionism aligns best with the sociability subconstruct of social presence.

Secondly, Erving Goffman's theory of dramaturgy proposes that all interpersonal interactions are performative, and people present themselves to achieve specific goals through impression management. This theory is relevant to online learning environments, where social identities are presented and perceived through the CMC platforms. Goffman's concept of copresence can enhance the theoretical basis for social presence theory. Social identities in online learning environments relates to social presence as a construct. Goffman's theory aligns best with the social presence subconstruct of social presence theory.

Thirdly, social situationism is a sociological theory emphasising the influence of the immediate social context, the "situation," in human behaviour. Rooted in social situationism, the Thomas Theorem states that if people define situations as real, they are real in their consequences. These concepts are relevant to social presence theory in online learning because they provide additional theoretical structure for understanding how reality is socially constructed in specific situations and how subjective perception influences behaviour, particularly in online learning environments.

Fourthly, Piaget's theory of social constructivism is relevant to social presence theory in online learning because it highlights the importance of interpersonal interaction in constructing knowledge. Social interaction and experiences contribute to constructing knowledge related to collaborative learning and perceptions of social presence in the social space. As such, Piaget's constructivism relates to social presence theory in online learning, particularly regarding knowledge construction.

Fifthly, Seymour Papert's theory of constructionism is relevant to social presence theory because Papert believed that technology, particularly computers, could support and enhance the process of knowledge construction, allowing learners to explore and experiment with ideas. In addition, he believed that collaborative learning in groups could amplify the potential of constructionism. Papert's theory has been cited in collaborative approaches to teaching

mathematical and computational thinking using computer science education tools. Papert's theory aligns with the social presence theory's interest in the role of social interaction and collaborative learning in the educational process, thus, with the social space subconstruct of social presence theory.

Sixthly, the CoI framework describes an approach to collaborative learning in online environments. The framework is based on constructivist theory and consists of three interdependent elements: social presence, cognitive presence, and teaching presence. The CoI framework fosters the process of collaboratively constructing meaning through critical thinking and discourse. The framework is set in the context of the communication medium, which is typically text-based for online learning. In the CoI framework, social presence refers to the extent to which learners can connect personally in an online learning environment. Cognitive presence is the extent to which learners can construct and confirm knowledge through individual critical reflection and collaborative discourse. Finally, teaching presence involves both social and cognitive presence in the online learning environment. The CoI framework and its antecedent theories align best with the social space subconstruct of social presence.

Seventhly, Bandura's social learning theory emphasises the role of social interaction in shaping individual behaviour. Based on this theory, collaborative learning emphasises group work, cooperation, and peer support in achieving shared goals. It assumes students learn better when engaging in social rather than individual learning. In the online learning context, collaborative learning can occur through various online tools and activities, with students working together in small groups to solve problems or achieve learning objectives. The collaborative learning theory is relevant to social presence theory because it relates to social space and perceptions of others with whom students collaborate as "real" online. Bandura's social learning theory and various theoretical approaches to collaborative learning align best with the social presence subconstruct of social presence.

Eighthly, regarding social presence theory, connectivism is a learning theory that emphasises the role of technology and social networks. Connectivism assumes that learning occurs through networks and knowledge is distributed across networks. It argues that students must be able to evaluate and adapt to changing information in a globally connected world. Connectivism also emphasises the role of social media in shaping learning and the need for students to develop digital literacies to navigate social networks. The inherently social nature of connectivism may

provide additional context to how social presence theory manifests in the online learning environment, specifically. Connectivism aligns best with the sociability subconstruct of social presence.

Finally, social media platforms allow people to connect and share user-generated content with an online community. The ubiquity of social media demands consideration, especially in the context of social presence theory, as it blurs the boundaries between communication within learning management systems and external social media platforms. Theories, applications, and critiques concerning social media and networking align best with social presence's sociability subconstruct.

This chapter was an exploration of various ancillary theories, sociological and pedagogical, related to perceptions of social presence in online learning. The overarching theoretical framework for this study is the social presence theory, which emphasises the degree to which individuals communicating through technological media perceive one another as real. This chapter examined different sociological theories, namely constructivism, constructionism, the CoI framework, social learning theory, connectivism, and social media, each providing additional theoretical structure to social presence theory in online learning environments. Such theories augment the construct of social presence and how it manifests in the online learning environment.

2.11 Summary

This chapter surveyed and summarised the literature surrounding the theoretical framework of social presence theory. Firstly, seminal definitions by Short et al. (1976) and contemporary definitions by Kreijns et al. (2021) were formulated. Secondly, counterarguments and social presence theory critiques were considered an essentially contested construct. Thirdly, classical sociological theories relevant to social presence theory, such as symbolic interaction and social situationism, were reviewed. Fourthly, theories of learning, such as Piaget’s social constructivism and Papert’s social constructivism, were integrated with contemporary theories in the orbit of social presence theory, such as collaborative learning in the online environment and the CoI framework. Ubuntu is an African philosophy that may help create supportive and inclusive online learning environments that emphasise community, collaboration, empathy, and respect. Finally, the social impacts of social media platforms, considering social presence

theory, were evaluated. A synthesis of theories, framed in terms of the three subconstructs of social presence theory, was included. This chapter thoroughly reviewed the theoretical framework of social presence theory and related concepts, which served as a foundation for understanding the social aspects of online learning and its potential impact on student retention. The next chapter is a continuation of the literature review focused on practical issues surrounding the problem of student attrition in online computer science undergraduate degree programmes.

Chapter 3 Review of Literature for Issues in Online Computer Science Education

3.1 Introduction

Following the thorough exploration of social learning theories and social presence as a theoretical framework, this chapter reviews the literature concerning issues in online computer science education. The literature review comprises the background to the problem of attrition in computer science education, issues surrounding persistence and satisfaction in both online learning and computer science education, and finally, the antidote to attrition and retention in online learning and computer science education. Furthermore, the Association for Computing Machinery's (ACM) Special Interest Group on Computer Science Education (SIG-CSE) proceedings were consulted.

Social presence is relevant to student attrition, retention, persistence, and satisfaction in online learning programmes because social presence has been associated with positive communication outcomes (Fogg & Tseng, 1999; Lee, Jung, Kim & Kim, 2006). For example, Khaled Hassanein and Milena Head (2007) found that experiences of social presence were positively associated with enjoyment, trust, and perceived usefulness in an online experience. Because of such association with positive communications outcomes, researchers have focused on applying social presence theory to enhance various online telecommunications experiences (Oh et al., 2018).

While each element of the literature reviewed in this chapter may not relate directly or explicitly to social presence theory, studies were found for each category that have at least mentioned social presence as a factor (see Table 3.1). The extent to which social presence theory itself relates to the problem of attrition and its antidote, retention, is unclear. However, specific theoretical approaches to online learning and instructional design, such as transactional distance and instructor presence theories, have clearer connections to social presence in the literature.

Table 3.1 Synthesis of Literature in Chapter 3

Subconstruct	Related topics
Sociability	Persistence, transactional distance

Social Space	Satisfaction, retention
Social Presence	Attrition, theories of motivation, instructor presence

As in Chapter 2, this chapter explores the literature through the lens of the three subconstructs of social presence theory: sociability, social space, and social presence, along with their related topics. Sociability is linked to persistence and transactional distance. Social space is associated with satisfaction and retention. Social presence is related to attrition, theories of motivation, and instructor presence. Relevant literature surrounding each category is also examined, considering online learning and computer science education. Finally, issues related to inequity in STEM fields and the challenges of uniquely marginalised groups in STEM education are also examined.

3.2 Attrition in Computer Science Education

The central problem for this study is student attrition in online computer science undergraduate degree programmes. Undergraduate student attrition is among the most concerning issues among higher education institutions worldwide (Syahira et al., 2019). Computer science has historically had the highest attrition rates among all STEM fields (Chen, 2013; Takács e al., 2022). Attrition from formal academic programmes in STEM fields occurs most often in the first two years of study. A lack of self-confidence has been identified as a primary factor (White & Massiha, 2016). The attrition problem from computer science programmes is greatest among "women and underrepresented minorities," which has provoked researchers to explore the multidimensional reasons for this (Cohon & Hambrusch, 2018, p. 5). Student attrition in online undergraduate computer science degree programmes is a problem in the United States and other international contexts. For instance, Ajoodha, Jadhav and Dukhan (2020) call student attrition in the sciences "an African reality" (p. 19). Student attrition in science-related fields, computer science included, is a particular problem for African universities (Lopez & Hassoun, 2022; Ajoodha et al., 2020). Student attrition in STEM disciplines is also problematic in South African higher education (Bengasai & Pocock, 2021, p. 1). Whitcomb and Singh (2021) found that underrepresented minority students have higher attrition rates in STEM disciplines. Systemic and structural barriers such as inadequate resources and funding for education, lack of access to quality education, cultural biases and stereotypes, and limited mentorship and professional development opportunities may affect underrepresented minority students.

Factors such as a lack of academic preparedness may also contribute to higher attrition rates for these groups (Kricorian, Seu, Lopez, Ureta & Equils, 2020).

In the United States, 75% of bachelor's degrees in STEM disciplines awarded by for-profit institutions in 2017 were in computer science, among other fields (Trapani & Hale, 2019, p. 14). At the bachelor's degree level, computer science programmes "increased sharply from 2000 to 2004 and dropped as sharply through 2009" but have "increased again since then, surpassing its previous high" (Trapani & Hale, 2019, p. 24). By 2012, 56% of all associate degrees in STEM-related fields were in computer science, but since then, associate degrees in computer science have declined (Trapani & Hale, 2019). According to Trapani and Hale (2019), online learning degree programmes are most frequently offered in the fields of computer science, among others, at the undergraduate (associate's and bachelor's degrees) levels; and primarily in computer science and engineering at the graduate (master's degree) level (p. 15).

Syahira et al. (2019) distinguishes between voluntary, incurred, and potential attrition. Voluntary attrition occurs when students choose not to persist in a course or degree programme and withdraw by their own decision. Incurred attrition is when an institution enforces rules or regulations leading to a student's dismissal or withdrawal. Potential attrition refers to high-risk students who can attrite in the near term. When attrition rates in online degree programmes are higher than their face-to-face counterparts, developing "explanatory models to explain retention is considered imperative" (Boston et al., 2011, p. 1). The attrition rate of online courses, generally, has been reported as anywhere from 40% to 80%, especially for students' first online courses (Bawa, 2016). Technological advancements in recent decades have expanded opportunities for students who otherwise could not attend "traditional seated courses" (at a brick-and-mortar institution) to "participate in a college or university experience" (Seery et al., 2021, p. 72). As a result, enrolment in online learning courses has increased by 100% since the 2000s (Salim Muljana & Luo, 2019). However, despite various efforts and interventions, student retention issues have not been resolved.

Having studied the experiences of online students across four countries, Boton and Gregory (2015) found that the very technologies themselves, such as the Learning Management System, can affect student attrition. Further, the theories instructors employ, such as constructivism, can influence attrition or retention. Therefore, research and development of systems for the early detection of at-risk students are critical for addressing disproportionate attrition rates in

online learning programmes (Salim Muljana & Luo, 2019). Using machine learning algorithms to deduce factors related to student attrition in the sciences at a South African university, Ajoodha, et al. (2020) created a forecasting model with specific predictors. Using a random forest classification model, four risk profiles for learners were created, yielding an 82% accuracy in predicting student success and, contrarily, student attrition. Such models, mining large datasets at individual institutions and shared data across institutions (such as the CERP survey data) could provide tools to help institutions support student success in the sciences and enhance "university throughput and retention rates positively" (Ajoodha et al. 2020, p. 27).

Academic rigour in STEM fields is a major contributing factor affecting student attrition (White & Massiha, 2016). Computer science courses can be academically challenging, requiring prerequisite knowledge and competence in mathematics and logic. Students who lack such an academic background or who feel overwhelmed by the workload (especially if remedial study is required) may become discouraged and withdraw from courses or programmes. Moreover, computer science courses tend to rely heavily on individual work, such as programming assignments, leaving little opportunity for group work or collaboration. Students who feel disconnected from the instructor or peers may be more likely to withdraw.

Beaubouef and Mason (2005) identify several factors related to high attrition rates in computer science degree programmes. Inadequate mathematics and problem-solving skills and poor project management skills were among the student-oriented issues leading to attrition. However, institutional factors such as lack of advising and support, poorly designed introductory computer science courses, and the point at which object-oriented programming is introduced in the curriculum were among the problematic factors that institutions can mitigate. Beaubouef and Mason did not propose solutions to these problems.

Keely et al. (2019) replicated prior studies on introductory programming course completion rates, suggesting that the failure rates in such courses are higher than institutions expect. Studies between 2007 and 2014 indicated an average pass rate of 67%, whereas Keely et al. (2019) found a pass rate of 72%. The authors conclude that "there was little evidence that failure rates in introductory programming were concerningly high" (p. 53). However, they also note that "high" is a relative term, depending upon that to which the rate is compared. If compared against the pass rates of other introductory courses in STEM fields, then the pass rates of introductory computer science courses are at the low end. Simon et al. (2019) sought

to dispel the notion that computing education should "begin with the premise that programming is hard to learn and hard to teach" (p. 5).

Albarakati (2020) highlights the problem of the underrepresentation of both women and racial minorities in undergraduate computer science degree programmes. Albarakati tracked the attrition of underrepresented students from computer science programmes at the University of Rhode Island. Using a logistic regression model, Albarakati found that women who left computer science programmes academically outperformed their male counterparts, which "implies that academic progress is not the main reason" women attrite from computer science programmes (p. 1427). Underrepresented racial minorities had lower academic achievement when they attrite, "which implies that they likely leave [computer science programmes] due to academic struggles" (p. 1427). DeClue (2009) proposes an approach to reducing attrition in computer science education that considers motivation theories and social contexts such as gender. Not unlike the sociological theory of social situationism, DeClue suggests that computer science instructors should be aware of students' "life context," which may help make computer science meaningful and relevant to students' lives. DeClue also considered the roles of physical, content, discipline, and professional contexts. Physical context, the actual use of computer hardware, has the "lowest potential for self-motivated learning" in computer science education (DeClue, 2009, p. 118).

Social presence alone is not the sole factor in student attrition because "many factors may play a role in a student's decision to drop out" of computer science programmes (Zahedi et al., 2020, p. 2). Other factors, such as student motivation, self-efficacy, and persistence, inevitably affect students' decision to withdraw from a computer science course or programme. Such factors are not unique to computer science education, technology education, or online learning but have broad applications according to best practices in teaching and learning in any subject and using any medium.

3.3 Student Motivation, Self-Efficacy, and Persistence

Motivation to achieve goals is relevant to understanding the problem of student attrition in online computer science programmes. This section summarises seminal theories of human motivation (originally intended for employee-workplace dynamics) by Locke, Lantham, House, and Herzberg. Bandura's theory of self-efficacy is also examined. Finally, connections are made between student satisfaction and persistence in online learning and the literature surrounding motivation and self-efficacy.

Edwin A. Locke (1968) developed a theoretical basis for goal theory in a study titled *Toward a Theory of Task Motivation and Incentives*. Locke's research suggested that more challenging goals motivate people towards higher performance to achieve those goals. Less specific goals lead to lower performance. Locke's central thesis was that goals motivate purposeful actions and levels of performance. Latham (1989) later tested Locke's theory and co-authored a book titled *A Theory of Goal Setting and Performance*. Locke and Latham's path-goal theory was expanded by Robert J. House (1971), who proposed that various approaches to leading others may affect performance in achieving goals. House (1996) later reformulated aspects of path-goal theory and invited further empirical verification. Ultimately, the theory contends that "a concern for group goals characterises the positive or socialized face of power, for finding those goals that will move [people], for helping the group to formulate them, for taking some initiative in providing members of the group with the means of achieving such goals, and for giving group members the feeling of strength and competence they need to work hard for such goals" (Miner, 2005, p. 50). Therefore, when people see "high productivity as a path leading to the attainment of one or more of [their] personal goals, [they] will tend to be a high producer" (Miner, 2005, p. 96).

Motivation-hygiene theory, now commonly referred to as the "two-factor theory," was developed by Frederick Herzberg (1959, 2017). Herzberg's research focused on how enrichment and satisfaction (in the employment context) influence motivation and productivity. The "two factors" of Herzberg's two-factor theory of motivation are satisfaction and dissatisfaction. These two constructs are not mere opposites; instead, they are separate constructs, each with its own features. Most of Herzberg's motivational factors, such as self-scheduling, achievement, and recognition, apply to enhancing students' motivation in the online learning environment.

Ultimately, goal theory suggests that people are self-directed and motivated to extend effort toward attaining their personal goals (Scheffer & Heckhausen, 2009). Students in online learning environments enrol in online programmes with specific goals (career advancement or enrichment, for example). According to Locke and Latham's theory, understanding that effort is especially directly related to the nature of specific goals is relevant to understanding issues like student attrition and retention in online learning. Specifically, students enrol in computer science degree programmes due to "personal and social factors" (Cohon & Hambrusch, 2018, p. 67).

Albert Bandura (1977) proposed a theory of "self-efficacy" to understand human behavioural change. Bandura sought a "unifying theory" of human behaviour to explain why some people set and achieve goals while others do not. Bandura also wanted to understand why people expend varying effort and energy on goals. Finally, Bandura (1969) sought to integrate the notion of self-efficacy with prior work on social learning theory. Bandura (1997) concluded that people with a high degree of self-efficacy, the expectation of "given actions to produce desired outcomes," live more productive and healthy lives (p. 24). Bandura's self-efficacy theory has been applied broadly in education at all levels. Ultimately, Bandura's theories are relevant to understanding both intrinsic motivation and persistence, which are relevant to understanding the problem of attrition in online computer science programmes.

Bandura's theory purports that self-efficacy and outcome expectancy (how a person expects or envisions a situation) is central to understanding human behaviour, motivation, achievement, and goal attainment (Lippke, 2020). Informed by Bandura's theories, Miner (2005) argues that self-efficacy is "concerned with judgments of how well one can execute courses of action required to deal with prospective situations" (p. 163). The extent to which people feel they have agency to direct aspects of their lives is central to self-efficacy theory (Shye, 2021).

Self-efficacy comprises four factors: mastery, social modelling, verbal persuasion, and physiological responses (Miner, 2005; Bandura, 1977). Mastery is the extent to which positive past experiences contribute to a heightened sense of agency. Social modelling involves seeing and sharing in the success of others and drawing on that success to inspire one's agency (Shye, 2021; Miner, 2005; Bandura, 1977). Verbal persuasion involves giving and receiving feedback to and from others to inspire goal-setting and attainment (Scheffer & Heckhausen, 2008). Finally, physiological states are the awareness of physical and emotional responses in one's body during positive and negative experiences (Miner, 2005; Bandura, 1977). Together, the regulation of these factors can foster individual self-efficacy. Most self-efficacy theorists do not assume that successful individuals with high self-efficacy are inherently more capable of achievement than those with lower self-efficacy (Lippke, 2020, p. 4725). Instead, individuals with lower degrees of self-efficacy may benefit from additional social modelling, verbal persuasion, mastery experiences, or learning to be aware of their physiological responses. In other words, self-efficacy can be nurtured. However, factors such as mental health and psychological distress can negatively affect self-efficacy development in college students (Grøtan, Sund & Bjerkeset, 2019).

Hayat, Shateri, Amini and Shokrpour (2020) conducted a correlational study to test the strength of relationships between self-efficacy and several factors, including "metacognitive learning strategies and learning-related emotions" and academic achievement. The study was conducted intentionally in a non-Western context among medical school students. Hayat et al. concluded that their results "strongly supported predictive links among academic self-efficacy, positive emotions, metacognitive learning strategies, and academic performance" (p. 8). Bandura (1993) later devised a Collective Teacher Efficacy (CTE) construct. For Bandura, teachers' perception of self-efficacy, their collective perceptions of self-efficacy, and how they project those perceptions on students affect student cognitive development. Bandura (1993) conceptualised three different levels of self-efficacy in this context, beginning with "students' beliefs in their efficacy to regulate their own learning and to master academic activities," which in turn affect their "aspirations, level of motivation, and academic accomplishments" (p. 117). In a meta-analysis of several studies, Donohoo (2018) concludes that some studies linked individual teacher efficacy to CTE and that CTE can be associated with positive behaviours such as student achievement. Furthermore, according to Donohoo, some studies, including Bandura's own, suggest that students' perceived CTE had a stronger effect on achievement than socio-economic status.

3.4 Student Persistence

In this section, student persistence is described broadly; the phenomenon of student persistence in online learning is examined; and student persistence in computer science is explored more specifically. Finally, student persistence is examined specifically in the context of online learning. According to Bandura's (1977) theory of self-efficacy, "persistence in activities that are subjectively threatening but in fact relatively safe produces, through experiences of mastery, further enhancement of self-efficacy and corresponding reductions in defensive behaviour" (p. 191). In other words, as people persist through smaller and safer challenges, they incrementally build self-efficacy and can increasingly persist through greater challenges. Defensive behaviours are likewise reduced in the process of successful persistence.

Persistence in online learning refers to a student's ability to continue coursework despite challenges or obstacles. Students in online courses fail at rates 10-20% higher than in traditional courses (Seery et al., 2021; Bawa, 2016). In addition, online learning can present unique challenges that may have an impact on a student's motivation, such as a lack of face-to-face interaction with instructors and peers and difficulty balancing coursework with other

responsibilities. According to Boston et al. (2011), “models for understanding student persistence in the face-to-face environment are well established; however, many of the variables in these constructs are not present in the online environment, or they manifest in significantly different ways” (p. 1). After addressing a myriad of competing definitions for the concept of “persistence,” Lakhal and Mukamurera (2021) settled on “the intention to complete the online course in which the student is enrolled” as an operational definition (p. 4).

Chiyaka, Sithole, Manyanga, McCarthy and Bucklein (2016) found that graduation rates were positively correlated with retention rates at online degree-granting institutions. Like any goal attainment, students must persist in pursuing academic goals to succeed in online learning. Realistic expectations, effective study habits, and interaction with instructors and peers affect student persistence in online learning (Gray & DiLoreto, 2016). Persistence requires students' willingness to seek support as needed. The structure, design, and levels of support provided in online courses are all factors that can affect student persistence (Shaikh & Asif, 2022). Support services for online learners are less effective than those provided for traditional students (Xu & Jaggars, 2011).

The extent to which students in online courses have support affects their ability to persist through courses and programmes. Ntuli and Gumbo (2019) proposed ways by which open and distance learning institutions can strengthen tutor programmes to support student learning. Tutors serve a key role as support personnel to reduce student perceptions of isolation and improve academic achievement in online learning environments. Students who can persist through challenges and setbacks are more likely to graduate. Online institutions and instructors can support persistence by providing clear expectations and support structures, engaging students in collaborative and interactive learning activities, and offering timely and personalised feedback (Gray & DiLoreto, 2016). The extent to which institutions and instructors can help students persist through courses and programmes, respectively, affects student retention and, ultimately, graduation. Mediating factors such as gender, age, and prior experience with online learning have been found to affect students’ ability to persist (Lakhal & Mukamurera, 2021).

Consistent engagement, that is, regular interaction within the course with instructors and peers, may be related to persistence in online degree programmes (Boston et al., 2011). A term often used in online learning instructional design is “Online Group Learning” (OGL), which is the intentional instructional implementation of small groups in online learning environments to

foster peer-peer learning (Johnson & Johnson, 2014, p. 87). Group cohesion in online learning fosters student achievement (Williams et al., 2006).

Social presence is relevant to persistence because it speaks to student perceptions of interaction and belonging (especially concerning social space) in the online learning environment. Social engagement in online learning environments can be "especially difficult for online students, but it can be important for their success" (Seery et al., 2021, p. 79). When structured by and facilitated with diversity, social engagement can enhance the student experience. Students from culturally and linguistically diverse (CLD) backgrounds can express themselves and their perspectives in healthy ways in online learning environments (Warren, 2018). However, Kreijns et al. (2021) warn that "measurement of social presence that is entangled with social space will then naturally produce an association with learning achievement, which, however, should not be attributed to social presence" (p. 162).

Enrolment in undergraduate computer science degree programmes has been "booming" since the mid-2010s, and there has been measurable demand for computing education (Fisher, 2016, p. 17). However, computer science has been identified as an academic subject with the worst student persistence rates toward degree attainment. For example, in a report intended to promote a national increase in college graduates with STEM degrees, the United States Department of Labor noted that among STEM subjects, "engineering technology had the highest percentage of degree attainment within a STEM field at above 40% while computer science had the lowest at 24.6%" (Olson, 2012, p. 61). Similarly, in a study on women in STEM programmes across Canada, Katherine Wall (2019) found that just "27% of women and 16% of men who started out in computer and information sciences completed a STEM degree within four years" (p. 3).

Higher education professionals are concerned about persistence rates among marginalised and underrepresented students. Even as the demand for computer science education grows, the impact of such demand on underrepresented students must be explored and understood (Fisher, 2016). Among African American and Latina women, Talley and Martinez Ortiz (2017) found that various factors such as "school experiences and family support" were major factors in students' decision to persist in STEM fields (p. 18). Wladis, Conway and Hachey (2015) explore how ethnicity and gender contribute to student persistence and success in online STEM programmes, specifically for non-traditional students at community colleges (two-year undergraduate). Their study compared the persistence of 3,600 students in both online and face-

to-face STEM courses. They found that older students persisted better than younger students, and women had lower persistence than expected (although no less than men) compared to face-to-face courses. Importantly, the study found that "though Black and Hispanic students may do worse on average in STEM courses than their White and Asian peers both online and face-to-face, this gap was not increased by the online environment" (p. 142). Wladis et al. (2015) concluded that women and younger students might need additional support in online STEM courses.

Expanded participation in education in computer programming at earlier ages, especially for traditionally marginalised groups, is a factor that can predict future persistence. Social support has been found to influence persistence among women in computer science and technology-related degree programmes. Still, the strongest predictors of persistence include prior experience with programming and advanced computer science courses during high school (Weston, Dubow, & Kaminsky, 2020). White and Massiha (2016) found that "successful STEM students spend more time per week than non-persisters in studying" (p. 4). Students' attitudes toward computing and their perceptions of the authenticity of the learning environment have also been identified as predictors of persistence in computer science programmes, especially among marginalised groups (Wanzer, McKlin, Freeman, Magerko & Lee, 2020).

Sharing personal journeys of "persistence and adversity, as well as successes" within computer science education could help "students discover their own resilience and resourcefulness, and gain confidence in their growing expertise" (Lopez & Hassoun, 2022, para. 8). Supporting students' interdisciplinary interests can foster persistence because students who do not major in computer science might "eventually pursue an advanced degree in computing" (Lopez & Hassoun, 2022, para. 8). Support from both peers and instructors may help computer science students feel like they are not alone in their academic programmes.

Perhaps most relevant to social presence theory, student persistence in a computer science Massive Open Online Course (MOOC) was found to be related to rates of discussion forum participation (Crues et al., 2018). Machine learning algorithms, including k-means clustering, were used to determine why women and men persist in online computer science courses relative to their engagement in course discussions. While reasons for taking such courses differed among men and women, their participation and engagement can predict persistence (Crues et al., 2018).

3.5 Student Satisfaction

In this section, student satisfaction is described broadly, the phenomenon of student satisfaction in online learning is examined, and student satisfaction in computer science is explored more specifically. In market terms, satisfaction is a feeling of disappointment or contentment with a product after "comparing the perceived performance of a product with the expected product performance" (Sofroniou, Premnath & Poutos, 2020, p. 378). In higher education, student satisfaction represents students' attitudes toward the sum of their learning experiences (Coulter & Coulter, 2003; Elliott & Shin, 2002).

In a study involving several universities in the United Kingdom, Sofroniou (2020) found correlations between student satisfaction in computer science courses and questions related to teaching and learning and assessment and feedback on a national STEM student survey questionnaire. Dissatisfaction, then, can be viewed as the antithesis of satisfaction. Dissatisfaction with courses and institutions can lead to attrition among students studying STEM disciplines (Syahira et al., 2019).

Social presence in online learning has been related to student satisfaction. For example, Rourke et al. (2001) devised a quantitative measure for social presence, a "social presence density calculation," which could be related to various other independent variables such as student satisfaction, retention, and achievement (p. 68). An international study of university students during the COVID-19 pandemic found a "significant positive relationship between online learning, social presence, and satisfaction with online courses" (Stankovska, Dimitrovski, Ibraimi & Memedi, 2021, p. 181). In a study on social presence and student satisfaction, Nasir (2020) reported that "students who declared relatively high level of satisfaction were more likely to report a high level of interaction with their peers in online conversation and high level of social presence" (p. 485). In fact, Nasir concluded that "social presence seemed to contribute the most in predicting the level of course satisfaction amongst the students" (2020, p. 485).

Student satisfaction is a key element used by institutions when evaluating the effectiveness of online learning (Alqurashi, 2018). For example, in a case study employing a mobile online learning platform for course delivery to 340 students, Zhonggen, Ying, Zhichun and Wentao (2017) found that student satisfaction rates were higher among those who used the mobile online learning platform than those who did not. However, the study did not consider the role of instructors in either using the platform or contributing to student satisfaction.

Gray and DiLoreto (2016) investigated the relationship between "course organization and structure, student engagement, learner interaction, and instructor presence" and student satisfaction in online learning environments (p. 1). Among all the variables affecting student satisfaction, Gray and DiLoreto found course structure and organisation to be the most significant factor affecting instructor presence, learner interaction, and student engagement. Courses structured to include a substantial proportion of interaction with instructors were found to have the greatest impact on student satisfaction. Further, courses that are structured in such a way as to provide opportunities for learner-learner interaction and ensure strong instructor presence (perhaps a manifestation of social presence) tended to yield a more "positive outlook" on the learning experience from students (p. 14). Similarly, Kim, Kwon and Cho (2011) identify learner-learner interaction as a "predictor of social presence but not of learning satisfaction" (p. 152).

In a study by Alqurashi (2018), four constructs were devised to predict student satisfaction in online learning courses: self-efficacy, learner-content interaction, learner-instructor interaction, and learner-learner interaction. Of these four predictor variables, learner-content interaction was among the most significant predictors of student satisfaction, and learner-learner interaction was the least significant predictor of student satisfaction. However, because institutions, accreditors, and regulatory agencies tend to emphasise substantive learner-learner interaction (such as the implementation of peer-to-peer threaded discussion board assignments), Alqurashi argues that more research is needed to understand precisely why, how, or even if learner-learner interaction affects student satisfaction (p. 133). Incidentally, the study did not consider instructor-learner interaction a predictor variable.

Zhan and Mei (2013) studied the relationship between self-concept and social presence in face-to-face and online learning environments and the effect on student satisfaction and achievement. Having examined data from 257 students, 121 face-to-face and 136 online, Zhan and Mei provided evidence that academic self-concept and perceptions of social presence are important factors that can influence students' satisfaction and academic achievement levels in either environment. Zhan and Mei note, however, that many factors can affect such outcomes, and it is difficult, regardless of how carefully a study is designed, to isolate abstract ideas like self-concept and social presence.

The extent to which student demographic factors, such as gender and race, affect satisfaction in online learning is unclear. For example, Kim et al. (2011) found that "demographic variables,

such as gender, online learning experience, and work status were not significant factors in terms of influencing either the social presence or learning satisfaction" (p. 1512). In fact, Qiangfu Yu (2022) notes that such demographic factors are controversial among researchers when considering student satisfaction in online learning courses.

In a study involving students in online learning courses in Jordan, Suhair Jaradat and Aseel Ajlouni (2020) conclude that "social presence and online learning self-efficacy impact and significantly predict student satisfaction in higher education institutions" in online learning environments (p. 759). Using a multiple regression model, Jaradat and Ajlouni built a model to encourage instructors to "foster social presence to enhance student satisfaction" (p. 769). Specific strategies for enhancing social presence may improve student satisfaction in online courses.

Considering the effects of the difficulty levels of online computer science courses, Farag, Ali and Ghani (2019) found that course level (an introductory versus advanced online computer science course) had no statistically significant effect on student satisfaction. Students do not necessarily express less satisfaction with an online computer science course merely because they are more difficult than their classroom-based counterparts. However, in the same study, there was a statistically significant difference between the two courses concerning interactivity and peer support measures. Interactivity and peer support may relate to sociability and social space, respectively.

According to Moallem (2015), delayed feedback and interaction in asynchronous learning limited students' perceptions of social presence and negatively affected student satisfaction. Students reported higher satisfaction levels and preferred a "combination of asynchronous and synchronous" learning activities in the online learning experience (Moallem, 2015, p. 70). Delayed asynchronous activities in online learning do not foster "social and emotional connections and relationships and group interactions" as effectively as synchronous activities afforded by more advanced technology, such as video conferencing (Moallem, 2015, p. 70). Combining asynchronous and synchronous tools in online learning environments can enhance perceptions of social presence simply because combined methods provide more opportunities for interaction and "interpersonal and emotional connections" (Moallem, 2015, p. 62).

3.6 Student Retention

Considering the literature, this section examines student retention issues in higher education. Student retention in higher education is a global issue (Seery et al., 2021). Retention is the antidote to attrition; it measures how many students persist in a degree programme to graduation compared to how many students withdraw before graduation (Bawa, 2016; Simpson, 2003). Retention affects the success of students and higher education institutions (Boston et al., 2011). Students may withdraw at any point in a course or programme; therefore, the "retention rate" measure may differ at the course, programme, department, or institutional levels (Bawa, 2016).

Rizkallah and Seitz (2017) identify motivation as a key factor in student retention in higher education. In an examination of 535 undergraduate students using Frederick Herzberg et al.'s (1959) two-factor theory, Rizkallah and Seitz found that student motivation shifts throughout their academic career and, as such, institutions should respond to those changes accordingly to improve student retention. However, the authors noted that some factors related to student retention might be outside the institution's control. For example, social presence is "a significant predictor of course retention" (Liu, Gomez & Yen, 2009, p. 165).

Moreover, understanding why low retention occurs in online learning is important (Tight, 2020). Surprisingly, there is still no "substantial amount of accumulated research" concerning student retention in online courses (Seery et al., 2021, p. 73). The need for additional research on strategies to improve student retention in online learning courses is gaining popularity (James, Swan & Daston, 2016).

Online learning often demands greater attention to student retention issues (Seery et al., 2021). Simpson (2003) pioneered seminal work on issues related to student retention in online and distance learning, which, even by the early 2000s, had notoriously low retention rates (p. 3). Simpson argues that degrees of institutional engagement, that is, how involved a student is with the institution before withdrawing, is directly related to the degree of impact (financial, socio-emotional, academic) on the student and the institution. Retention of students in online learning programmes is a critical issue for universities worldwide (Seery et al., 2021).

While online degree-granting institutions have expanded educational access for students who might otherwise be excluded from higher education, low student retention rates have been a major threat to the promises of such expanded access (Trapani & Hale, 2019; Chiyaka et al.,

2016). Moreover, as the growth of online degree programmes has accelerated since the 2010s, there is increasing concern over student retention in online learning (Boston et al., 2011). Planning and management of online instruction should consider both retention and graduation rates. Student-faculty ratios in online learning may not significantly affect student retention (Chiayaka et al., 2016). However, retention rates are 10-20% lower for online learning courses than traditional face-to-face courses (Bawa, 2016). Adding student services personnel and increasing faculty training have improved student retention in online courses (Seery et al., 2021). However, De Freitas, Morgan and Gibson (2015) found that increasing peer-to-peer interaction in online courses, especially MOOCs, can positively affect retention. In fact, peer-led interaction was studied in an astronomy MOOC (within the score of STEM fields) and was found to improve course completion rates. Student-student interaction and engagement, like faculty-student interaction, contribute to improving retention rates in online courses.

James et al. (2016) studied 656,258 records of students taking online courses at community colleges (two-year undergraduate) in the United States across three delivery modes: primary in-person, primarily online, and fully online. The study suggested that for community college-level students, those who took courses primarily in-person and some online courses had higher retention rates than those who took courses primarily online. However, the study did not reveal any difference between delivery modes for four-year undergraduate university students. In the same study, James et al. (2016) found that gender did not affect student retention rates in online courses. There was also no difference in retention rates across socioeconomic status (based on data concerning Pell Grant utilisation). Incidentally, older students who took only one online learning course were retained at higher rates than younger students. Finally, despite data suggesting higher attrition rates for online learning programmes, James et al. found that "taking online courses is not necessarily harmful to students' chances of being retained and may provide course-taking opportunities that otherwise might not be available, especially for nontraditional students" (2016, p. 75).

Salim Muljana and Luo (2019) identify several factors to improve retention in online learning courses: "institutional support, the level difficulty of the programs, promotion of a sense of belonging, facilitation of learning, course design, student behavioural characteristics, and demographic variables" (p. 19). Conversely, they recommend the following strategies: "early interventions, at-all-times supports for students, effective communication, support for faculty teaching online classes, high-quality instructional feedback and strategies, guidance to foster

positive behavioural characteristics, and collaboration among stakeholders to support online students" (p. 19). Salim Muljana and Luo note that because of a confluence of these factors and strategies, it is inherently difficult to isolate any of them; therefore, a multifaced, holistic, and integrated approach to identifying and addressing student retention issues in online learning programmes is necessary. Because attrition rates are notoriously high in STEM fields, and computer science specifically, understanding the importance of retention is critically important.

Xianglei Chen (2013) found an attrition rate of 59% of undergraduate computer science students, the highest among all STEM fields. The literature suggests that low student retention rates in computer science programmes may be related to several factors, including the difficulty of the curriculum, lack of diversity and inclusivity, and lack of support from instructors. Because computer science is unique, increasing retention rates in computing-related fields is "critical" to the future of related industries (Zahedi et al., 2020, p. 1). Counterintuitively, "adverse conditions associated with high demand for courses" in computer science programmes create challenges for student retention (Cohon & Hambrusch, 2018, p. 7).

White and Massiha (2016, p. 4) state that "societal and cultural biases lead underrepresented students toward lower retention rates" in STEM fields. Improving representation, diversity, and inclusion in computer science programmes may support student retention. Computer science has traditionally been male-dominated, and students who do not feel represented or included may be less likely to stay in the programme. In addition, students from underrepresented genders, backgrounds, or races may face additional challenges and barriers to persistence and achievement. According to Lopez and Hassoun (2022), "despite increasing enrolments in computer science, the percentages of historically excluded students have not changed much, and many institutions are struggling to retain them" (para. 1). Advising practices are among the earliest interventions institutions can provide to support long-term student retention in computer science programmes (Cohon & Hambrusch, 2018, p. 51).

Improving support may aid in student retention in computer science programmes. Students who do not receive adequate support from their instructors or advisors may struggle to navigate the programme requirements or find resources to help them succeed. Unlike face-to-face programmes where "hands-on" mentoring is effective, students in online STEM programmes expect services and support that are "convenient and accessible on-demand" (Seery et al., 2021, p. 74; Wladis et al., 2015). Enlisting a "diverse team of faculty, instructors, and mentors" may

improve retention efforts in computer science programmes (Cohon & Hambrusch, 2018, p. 114).

Education researchers should use historical data to discern patterns that might explain student withdrawals and attrition to "provide guidelines and mechanisms" to reduce it (Zahedi et al., 2020, p. 1). To address low retention rates in computer science degree programmes, institutions can focus on improving the accessibility of the curriculum, promoting diversity and inclusion, providing more intentional opportunities for engagement and collaboration within the learning process, and providing support services to help students succeed. Graduate assistants can provide meaningful support and mentoring to undergraduate students in computer science. However, if poorly implemented, support from graduate assistants can be counterproductive (Cohon & Hambrusch, 2018, p. 135).

In addition to the motivational theories explored earlier in this chapter, instructional design theories may support these practical approaches to improving student retention in computer science degree programmes. The next sections review literature concerning transactional distance, instructor presence, and rudimentary aspects of synchronous versus asynchronous online learning.

3.7 Transactional Distance

Transactional distance is a theoretical concept developed by Michael G. Moore (1973) concerning learners' experiences in distance education environments. For Moore, there are unique quality of teaching and learning at a distance, and traditional face-to-face methods of classroom instruction cannot be merely, or successfully, recreated in a distance learning environment. Moore defined "transactional distance" as the perceived degree of autonomy and interaction between the student and the learning process (not necessarily the instructor). But, as transactional distance increases, an instructor must transition from being active in the learning process to being a facilitator or manager of the student's learning. Transactional distance theory has been extended to other applications, such as institutional policy development, in terms of which "meaningful student measures can be taken to decrease distances to ensure students' cognitive, meta-cognitive, and affective needs are effectively met" (Gokool-Ramdoo, 2008, p. 14).

According to Moore (1997):

> With separation, there is a psychological and communications space to be crossed, a space of potential misunderstanding between the inputs of the instructor and those of the learner. It is this psychological and communications space that is the transactional distance (p. 22).

Moore identified structure and dialogue as two constructs that relate to transactional distance. The structure is the level of support afforded by the design and organisation of the curriculum and its associated technological delivery systems. At the same time, dialogue is the level of perceived interaction between the learner and the instructor. The less interaction a student has with an instructor, the higher the perceived cognitive distance. The less clearly structured and technologically supported the curriculum, the higher the perceived structural distance. However, the more structure and the more dialogue increase, the more learner autonomy decreases. When an instructor is not engaged in the learning process or instructions are unclear or technologically complicated, transactional distance is increased for the learner.

Giossos, Koutsouba, Lionarakis and Skavantzos (2009) proposed a unique way to view Moore's theory of transactional distance through the lens of realism and John Dewey's pragmatism. In any teaching and learning exchange, structure and dialogue are "the mechanisms of transactional distance" (p. 4). From this perspective, transactional distance "must be examined at the level of (i) the interpersonal relationship between teacher and learner, (ii) the mediating relationship between learners and the educational material" (p. 4). This mediating factor makes transactional distance theory particularly relevant to social presence theory. In the latter's case, most studies have considered the role of CMC and its effects on perceived social presence in a telecommunications exchange. In the case of the former, the mediating technologies in online learning also play a role as mechanisms in the teaching-learning process which yield certain effects, namely, the perceived transactional distance between the learner and the curriculum, the learner and the instructor, and the learner and their peers (see Figure 3.1).

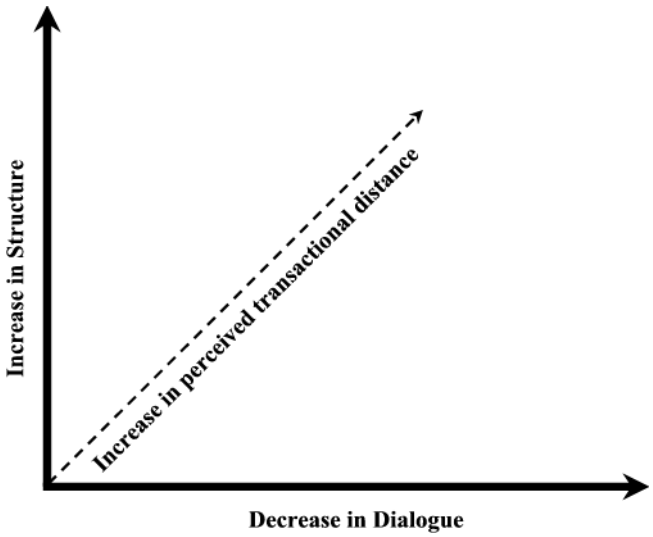

Figure 3.1 Transactional Distance Theory

In a study by Gorsky and Caspi (2005), transactional distance theory was "neither supported nor validated by empirical research findings" (p. 1). Gorsky and Caspi argued that while transactional distance theory has high "face value" validity, it would seem logical that more interaction would reduce perceived distance. However, it is difficult to measure such effects (2005, p. 9). Ultimately, Gorsky and Caspi argue that transactional distance may be reducible to a single proposition, namely, that interaction does reduce perceived distance.

Highly structured technological online classrooms, such as videoconferencing and other forms of synchronous interaction, have costs and benefits to transactional distance. Increasing interaction does not always lead to a better experience for the student, especially for adult learners. While interaction is increased, student autonomy may be decreased (Falloon, 2011). Critiques of transactional distance theory include researchers' tendencies to measure dialogue, which is learner interaction in quantitative terms (that is, frequency and duration) at the expense of the quality of such interaction and the perceptions of learners (Delgaty, 2018). Social presence theory, on the other hand, tends towards measuring perception.

Transactional distance theory can be tangentially related to social presence theory. Both structure and dialogue play a part in enhancing student perceptions of social presence in online learning environments. Careful instructional design, including "authentic learning experiences that align with students' interests," can improve student perceptions of social presence (Stankovska et al., 2021, p. 181). Transactional distance theory and social presence theory are related because both theories explore the mediating role of technology in the teaching and learning process. While transactional distance theory emphasises the perceived distance

between the student and the curriculum, instructor, and peers, social presence theory focuses on the degree to which students perceive the “realness” or salience of others in the online learning environment.

3.8 Instructor Presence

Instructor presence is a construct like transactional distance theory's dialogue and structure components and the “teaching presence” element of the CoI framework. Instructor presence occurs when instructors in online learning environments provide clear and concise instructions and expectations (high structure in transactional distance theory), facilitate discussions (high dialogue in transactional distance theory), provide constructive feedback on assignments, and facilitate collaborative learning (Richardson, Besser, Koehler, Lim & Strait, 2016). Like reducing perceptions of transactional distance, instructor presence is promoted as an antidote to the isolation learners often feel in online learning environments. Increasing faculty-student interaction is among the most common strategies for improving student retention in online courses (Seery et al., 2021).

Like social presence theory, instructor presence theory suggests that student experiences in online learning depend upon the extent to which an instructor creates a sense of presence within a course. Oyarzun, Stefaniak, Bol & Morrison (2018) found that “a high level of instructor social presence has positive effects on student achievement and learning satisfaction” (p. 154). Instructor presence is closely related to the strategies associated with increasing social presence and reducing transactional distance, such as frequent interaction and communication (dialogue), and rich media, such as audio, video, and teleconferencing. Student motivation to learn and engage with the course material (and with their peers) is influenced by an instructor’s presence within an online learning environment.

3.9 Synthesis of Literature and Relevance to the Study

The central problem in this study is that student attrition in online undergraduate computer science degree programmes is a global issue in higher education. Computer science has historically had the highest attrition rates among all STEM fields, and attrition occurs most often in the first two years of study. Academic rigour may contribute to student attrition, and it is noted in this study that computer science courses tend to rely heavily on individual work, making students feel disconnected from the instructor or peers. The academic rigour of computer science courses and the potential challenges students may face can affect their ability

to benefit from social interaction and may affect the development of a sense of community in online learning environments. Understanding the role of social presence in these contexts may help support student success and retention. The literature review in this chapter can be synthesised according to six broad categories, each directly related to the three subconstructs of the conceptual framework, namely social presence, sociability, and social space.

Firstly, various theories of motivation in the context of online learning environments may help provide context for understanding student persistence and retention in online computer science courses. Goal theory suggests that people are self-directed and motivated to achieve attainable goals. Bandura's self-efficacy theory emphasises the role of agency in achieving goals. Theories of motivation are relevant to understanding issues like student attrition and retention in online learning environments, particularly for computer science education—motivation theories. Literature related to motivational theories best aligns with the social presence subconstruct in the social presence theory conceptual framework.

Secondly, computer science has been identified as an academic subject with the worst student persistence rates toward degree attainment, particularly among underrepresented students. Persistence in online learning is a student's ability to continue coursework despite challenges or obstacles. Students in online courses fail at rates 10-20% higher than in traditional courses. The structure, design, and levels of support provided in online courses are all factors that can affect student persistence. Students who can persist through challenges and setbacks are more likely to graduate. Social engagement in online learning environments can be important for student success, particularly for those from diverse backgrounds or traditionally marginalised groups. The literature surrounding student persistence in online computer science programmes best aligns with the sociability subconstruct in the social presence theory conceptual framework.

Thirdly, student satisfaction in online learning, particularly in computer science courses, is an overall disposition towards the totality of learning experiences. Student satisfaction and social presence have been shown to relate to learner-learner and learner-instructor interaction. Course organisation and structure, learner-content interaction, and social presence significantly affect student satisfaction. However, the literature suggests that more research is needed to understand how student-student interaction affects student satisfaction. The literature surrounding student satisfaction in online computer science programmes best aligns with the social space subconstruct in the social presence theory conceptual framework.

Fourthly, student retention is the antidote to student attrition. Because online programmes have notoriously low retention rates, student retention is a global issue. Studies suggest retention rates are 10-20% lower for online learning courses than traditional face-to-face courses. Retention measures the number of students who persist in a degree programme to graduation compared to those who withdraw before graduation. Factors to improve retention in online learning courses include support services, promotion of a sense of belonging, facilitation of learning, and the structure surrounding course design. The literature surrounding student retention in online computer science programmes best aligns with the social space subconstruct in the conceptual framework of social presence theory.

Fifthly, transactional distance is a theoretical concept that refers to the perceived distance between the learner and the learning process. A student's sense of distance is influenced by the levels of autonomy and interaction between the student and the instructor, manifested through structure and dialogue. The more structure and dialogue increase, the more learner autonomy decreases. Transactional distance theory can relate to social presence theory, as structure and dialogue can enhance student perceptions of social presence in online learning environments. Therefore, the literature surrounding transactional distance theory best aligns with the sociability subconstruct in the social presence theory conceptual framework.

Finally, instructor presence is a concept related to transactional distance theory's structure and dialogue components and the teaching presence element of the CoI framework. Instructors who provide clear instructions and expectations, facilitate discussions, give feedback, and facilitate collaborative learning can create a sense of presence within an online course and, in turn, reduce learner isolation. Instructor presence theory suggests that an instructor's presence in an online learning environment is closely related to student motivation and engagement. Frequent interaction and rich media can increase instructor and social presence. The literature surrounding instructor presence best aligns with the social presence subconstruct in the social presence theory conceptual framework.

3.10 Summary

In this chapter, the literature surrounding the problem of attrition in online undergraduate computer science degree programmes was reviewed. Connections to social presence theory were made as appropriate as they appeared in the literature review. Next, theories of motivation were reviewed and applied to the online learning context. Thereafter, student persistence and satisfaction issues were reviewed, specifically in online learning and computer science

education. Relevant studies on student retention in online learning and computer science education were also reviewed. Finally, instructional design theories, transactional distance, and instructor presence were also considered. These categories from the literature were synthesised in terms of the three subconstructs of social presence theory. This chapter presented a comprehensive literature review on factors influencing student retention in online computer science degree programmes, connecting these factors to social presence theory. The synthesis of relevant theories and studies, framed in terms of the subconstructs of social presence theory, lays the foundation for the research methodology and design of the study. The next chapter turns to the research methodology and design formulation.

Chapter 4 Research Methodology and Design

4.1 Introduction

With a solid foundation established by the literature review chapters, this chapter of the study outlines the research methodology and design, including details on population and sampling techniques, data collection methods, and statistical procedures. It also addresses potential threats to reliability and validity, research ethics, limitations, and defines key concepts used in the study.

This study utilised a quantitative positivist epistemological paradigm and ex post facto design. Population and sampling techniques related to the archival dataset are presented. Instrumentation and data collection techniques are explained. Statistical procedures for the analysis of the data and hypothesis testing are proposed. Threats to the reliability and validity of this study's design, procedures and instruments are disclosed. Issues related to research ethics and data protection are delineated. This study's limitations are acknowledged, and the scope of this study is delimited. Finally, key concepts that are used throughout this study are defined and supported by the literature.

4.2 Research Approach and Paradigm

A quantitative methodology is appropriate for this study because a reliable instrument with ordinal scales was used to measure the hypotheses' dependent variables (Rutberg & Bouikidis, 2018). A positivist epistemological paradigm guided this study through quantitative measurement-driven survey research (Creswell, 2018). However, it is tempered with social presence theory's qualitative and subjective elements in its theoretical and conceptual frameworks. The positivist epistemology assumes that quantitative data collected from a survey instrument, and the statistical analysis of such data, constitute knowledge (Ngulube et al., 2015). The positivist epistemological paradigms follow a "deductive approach whereby research mainly starts with a theory" (Ngulube et al., 2015, p. 46). Ontologically, this study also assumes that the social phenomena it seeks to observe, through the lens of the theoretical and conceptual frameworks, are real phenomena if only socially constructed when mediated through computer technologies (Ngulube et al., 2015).

In addition to ontology and epistemology, axiology is another tenet of a paradigm considered in research methodology, in this case, positivism. Axiology refers to the values and ethics that

underlie the research, including the researcher's role, values and biases (Creswell, 2018). Axiologically, quantitative positivism emphasises objectivity and neutrality in research procedures, which is particularly relevant for a correlational study that aims to examine empirical relationships between variables while minimising bias when interpreting the results. In this study, the researcher's values and biases are acknowledged and transparently reported in the limitations section of this chapter. Additionally, ethical considerations, such as obtaining informed consent and protecting participants' data, were considered in the research procedures. Axiologically, the chosen paradigm of a quantitative positivist epistemological approach has been guided by the theoretical framework of social presence theory which has provided a strong foundation for the methodology and design of this study and its underlying ethical assumptions.

4.3 Research Design

This study utilised a correlational ex post facto research design. A quasi-experimental design is inappropriate for this study because data will not be grouped on dichotomous independent variables or compared for statistically significant differences (Creswell, 2018). An ex post facto design does not require sampling, random assignment to groups, or applying an intervention or treatment (Salkind, 2010). All three research questions and associated hypotheses deal with the relationship between continuous dependent variables; hence, these research questions are antecedents to the stated hypotheses. A correlational design is appropriate when examining the relationship between two sets of variables (Rutberg & Bouikidis, 2018).

In ex post facto designs, the approach identifies dependent variables and determines potential causal or intervening factors already existing within the available data (Salkind, 2010). Variables are identified by aligning items from the instrument to the subconstructs of the theoretical framework to create subscales and a composite score. Intervening factors include the items used for groupings or correlational tests, such as student satisfaction and persistence ratings from specific questions.

4.4 Population and Sampling

The target population for this study is narrowly defined as all students who completed the CERP survey from 2011-2022 and indicated "online only" as the mode of their programme of study in computer science. Students were only those from whom the archived data were supplied, and no data were collected from students directly. For students who studied computer science "online only," the dataset was anticipated to yield approximately 2,000 cases. The

sample is of the whole. The sample is a non-probability sample of convenience, and results cannot be generalised beyond the narrowly defined target population (Bhandari, 2021; Creswell, 2018).

Based on the current dataset from the CERP survey, the sample size represents the entire target population. Inclusion criteria for the CERP survey are current enrolment in a participating undergraduate computer science programme and a minimum age of 18 years old. Exclusion criteria for the CERP survey are students not currently enrolled in a participating undergraduate computer science programme.

4.5 Instrumentation and Data Collection Techniques

The instrument is explicated in this section based on the archival dataset. Then, variables related to the theoretical and conceptual frameworks and specific items on the instrument are conceptualised. Finally, a plan for data collection is presented.

4.5.1 Instrumentation

This study utilised an existing dataset based on a survey developed by the Computing Research Association's (CRA) Center for Evaluating the Research Pipeline (CERP) called "Data Buddies," which was funded by the National Science Foundation (NSF) in the United States, under Grant Numbers CNS-1246649, CNS 1840724, DUE-1431112, DUE 1821136 (CRA, 2022, para. 6). The data are made publicly available to researchers upon request. Both the NSF and the CRA encourage researchers to utilise the data to enhance diversity and inclusion in computing education (CRA, 2022). The survey is administered annually to more than 140 participating institutions (Lewis et al., 2021; Wright & Tamer, 2019).

Kreijns et al. (2014) note that any instrument seeking to measure social presence "should focus on the measurement of how group members perceive 'realness' of the other" (p. 9). This study does not attempt to create or validate a new instrument to measure social presence. Rather, the theoretical and conceptual frameworks are aligned to data from the CERP instrument to formulate measurable variables related to social presence theory.

4.5.2 Variables

The CERP survey asks students who have studied computer science about "their educational experiences, confidence, attitudes, and career goals" (Lewis et al., 2021). This study included the following dependent variables: composite social presence score (comprised of social

presence, sociability, and social space subscales) and student satisfaction. While bi-variate and multi-variate correlations were conducted to test the hypotheses, the data will not be split on any independent variables because the hypotheses are not intended to test for significant differences between groups. Instead, the hypotheses will test for relationships between variables.

The CERP survey is designed to measure "insights into student attrition and retention" (CRA, 2022, para. 2). The dependent variable, "student satisfaction," is based on Question #44 of the CERP instrument: "Overall, I am satisfied with the computing program at my institution." It is a Likert-style item with a rating scale of 1-5, where 1=Strongly disagree, and 5=Strongly agree. The dependent variable, "student persistence," is based on Question #52 of the CERP instrument: "During your studies at your current institution, how often have you considered leaving your degree program before completing it?". It is a Likert-style item with a rating scale of 1-5 where 1=Never and 5=All the time. These two dependent variables were tested for correlation with a composite social presence score based on other items in the instrument aligned to three subconstructs identified by Kreijns et al. (2021) as interrelated and irreducible aspects of what is broadly understood as social presence: social presence, sociability, and social space.

In the conceptual framework, the three subconstructs constitute a composite construct of social presence because each is interrelated with the other and cannot be isolated. When integrated holistically, the subconstructs influence establishing and maintaining social interaction in groups in computer-mediated communication (Kreijns et al., 2021, p. 141). However, Kreijns et al. (2021) warn against committing a "jingle fallacy" (Kelley, 1927, pp. 62-65) with the three subconstructs, which occurs when two or more constructs, otherwise conceptually different, are confused or conflated as one in the same construct (p. 141). To mitigate against this fallacy, the three subconstructs were aligned to instrument items independently, and for posterity, their composite scores were measured as a proposed inclusive construct, social presence. As such, "relationships among constructs are expressed in terms of propositions" and "a number of concepts form constructs" (Ngulube et al., 2015, p. 46).

For clarity, it is important to "relate the variables to the specific questions or hypotheses on the instrument" (Creswell, 2018, p. 217). Table 4.1 is an overview of the theoretical framework aligned to the associated variables, research questions, and items of the CERP instrument. The table is modelled after Creswell's example.

Table 4.1 Alignment of Conceptual Framework and Abstracted Variables

Variable	CERP Items	Research Questions	Hypotheses
Subconstruct: Social Presence	#80b-d,f; #76a,d	RQ3	H3
Subconstruct: *Sociability*	#50b-d	RQ3	H3
Subconstruct: *Social Space*	#76b,e; #49a	RQ3	H3
Construct: Composite Social Presence	12 sub-items, totalled	RQ1, RQ2	H1, H2
Construct: Satisfaction	#44	RQ2	H2
Construct: Persistence	#52	RQ1	H2

Note: Refer to the Review of Literature and Definition of Key Concepts in Chapter 1 for justifying citations.

Most of the subitems on the CERP survey are on an interval scale of "Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree," where "Strongly disagree"=1 and "Strongly agree"=5. Next, subitems for social presence and its subconstructs were grouped, and the total possible number of points was divided by the number of subitems to produce a final scale of 1-5 for each subconstruct. The final two constructs, satisfaction, and persistence, were based on single questions from the CERP survey already on the 1-5 scale (see Table 4.2).

Table 4.2 CERP Items and Transposed Scales

Variable	CERP Items	Scale	Possible Total	Transposed Scale
Subconstruct: Social Presence	#80b-d,f; #76a,d	1-5	30	30 / 6 = 5
Subconstruct: *Sociability*	#50b-d	1-5	15	15 / 3 = 5

Subconstruct: *Social*	*Space*	#76b,e; #49a	1-5	15	15 / 3 = 5
Construct: Composite Presence	Social	12 sub-items, totalled	1-5	60	60 / 12 = 5
Construct: Satisfaction		#44	1-5	5	5 / 1 = 5
Construct: Persistence		#52	1-5	5	5 / 1 = 5

4.5.4 Data Collection

The Computing Research Association (CRA) has been collecting data for the Data Buddies project since 2011, and by 2019, the survey included longitudinal cases from more than 40,000 computer science students (Wright, 2019). According to the CRA, the dataset is public and requires no special ethical clearances. The data files were in SPSS (IBM's Statistical Package for the Social Sciences) format. The data files were imported into the SPSS software.

4.6 Data Analysis and Interpretation

Archival data from an extant dataset was used for this study. The Data Buddies dataset based on the CERP survey was cleaned and prepared to meet the criteria of the target population. After cleaning and preparing the data, data were analysed with statistical procedures using IBM SPSS software. Correlational statistical procedures were conducted to test all three hypotheses (Orcher, 2014).

4.6.1 Data Preparation

While there are datasets available for undergraduate and graduate computer science students, this study will only utilise the undergraduate dataset. The dataset was filtered to include only the cases for survey responses where the type of programme was online learning. Question #38 of the instrument asks, "Is your program primarily on campus or online?" Only survey responses that answered "online only" were included in the data analysis.

Sample selection, a threat to validity based on partial or missing data in a dataset, was mitigated by eliminating all incomplete cases from the dataset (Ogundimu & Hutton, 2016). The normality of a distribution of data can be improved through data cleaning and proper

preparation (Ogundimu & Hutton, 2016). Tabachnick and Fidell (2007) suggested eliminating values in a dataset greater than or less than 3.29 standard deviations away from the mean. If preliminary tests for normality are not met, outliers may be removed, and the tests for normality performed again.

Assumptions tests was conducted to determine if parametric or non-parametric procedures can be applied to the data. Firstly, an assumption of normality was tested. Next, normality was tested with the Kolmogorov-Smirnov procedures for each variable. A non-statistically significant result on the Kolmogorov-Smirnov test (where $p > .05$) would indicate that the assumption for normality was adequately met (Massey, 1951). Finally, a Spearman procedure was conducted as a non-parametric alternative to the Pearson procedure if the normality assumption cannot be met. A Spearman correlation procedure is a non-parametric alternative to the Pearson procedure and does not depend on parametric assumptions such as normality or equal variances of the sample's distribution (Field, 2013).

Statistical power analysis calculates the sample size needed to determine whether a "correlation significantly differs from zero" (Creswell, 2018, p. 213). However, because this study is delimited to students who have completed the CERP instrument and those who were enrolled in "completely online" computer science programmes, no broader target population is specified, and the results of this study do not attempt to speak beyond a sample of the whole. Therefore, power analysis is not relevant or necessary with appropriate delimitations.

4.6.2 Data Analysis

Data were analysed using the IBM SPSS software. Hypotheses were tested using correlational statistical procedures. Pearson's product moment of correlation procedure yields a coefficient to measure the strength of the association or relationship between two variables (Liu, 2019; Orcher, 2014; Salkind, 2010; Tabachnick & Fidell, 2007). The Pearson procedure examines the relationship between continuous variables at ordinal, interval, or ratio scales. Pearson's correlation coefficient returns a value on a scale from -1 to +1. A value of 0 indicates no statistically significant relationship between variables. Conversely, a value greater than 0 indicates a positive relationship; in this case, the association suggests that as one variable's value increases, the other variable's value also increases. Conversely, a value less than 0 indicates a negative relationship, in which case, the association suggests that as one variable increases, the value of the other variable also decreases (Shan, Zhang, & Jiang, 2020; Salkind, 2010).

After conducting a correlational procedure on the data to test each null hypothesis, a correlation coefficient was be used to express the strength of the relationship between the two variables and either reject or fail to reject each null hypothesis (Shan et al., 2020; Rudd & Honkiss, 2020; Salkind, 2010).

4.6.3 Interpretation

Statistical results were interpreted by examining correlation coefficients and relevant post hoc procedures. Cohen's (1988) *d* was calculated to interpret the correlation coefficients to evaluate the relationship strength between variables. Correlation coefficients between .10 and .29 suggest a weak relationship; coefficients between .30 and .49 suggest a moderate relationship; and coefficients greater than .50 suggest a strong relationship between variables (Orcher, 2014). Scatterplots representing the visual relationship between each bivariate distribution were presented.

The results of hypothesis testing were interpreted considering the problem and rationale defined for this study. Results were compared with findings in the existing literature. Implications for computer science instructors and best practices in online learning were discussed. Finally, recommendations for future research were proposed.

4.7 Reliability and Validity

Reliability and validity must be considered in quantitative studies to ensure that this study's design, instrumentation, and procedures are sound. Potential threats to external, internal, and construct validity were considered for this study. Viable approaches to addressing each threat are proposed. Reliability is the consistency of measurement; it is possible that a measure may be reliable but not necessarily valid (Drost, 2011). Threats to reliability and validity in this study are acknowledged, and approaches to mitigating them are proposed.

4.7.1 Reliability

Reliability is the extent to which survey instruments dependably measure the constructs they are designed to measure (Zumbo & Rupp, 2009). An instrument must consistently discriminate individual cases at a single point of administration or over time (Drost, 2011). The CERP survey and Data Buddies dataset has been used for similar ex post facto quantitative studies published in the proceedings of the Association for Computing Machinery (Lewis et al., 2021; Wright & Tamer, 2019; Blaney & Stout, 2017).

Because of the length and breadth of the CERP instrument, there is sufficient opportunity for future research to consider other data points from the dataset concerning this study's research questions and hypotheses. Regarding consistent testing of the stated hypotheses, this study was replicable as more data were added to the Data Buddies dataset. Clear articulation of the research procedures and careful attention to the appropriate statistical tests will enhance the reliability and replicability of this study.

4.7.2 Validity

External validity is the extent to which findings can be generalised to the population (Bhandari, 2022; Creswell, 2018; Drost, 2011). This study makes no claims of broad generalisability beyond the narrowly defined population. Relevant threats to external validity include population validity, sampling bias, testing effect, and situation effect.

A threat to population validity is that the population is only computer science students who completed the CERP survey, and results cannot be generalised beyond the participating institutions. Sampling bias does not apply because participants were not sampled; the entire dataset was used for analysis. The testing effect is irrelevant because the CERP survey is not a pre-test/post-test measure. The situation effect may affect responses to the CERP survey because students may have responded to the instrument in different personal and social contexts. However, conceivably, all students who indicated that their computer science degree programme was “completely online” would have responded outside of a confounding context; unlike their residential counterparts, they would not respond within the walls of a traditional bricks-and-mortar institution.

Internal validity is the extent to which hypotheses can be consistently tested apart from viable explanations confounded by other factors (Bhandari, 2022; Drost, 2011). Like any survey-based study in the social sciences, not all confounding variables can be identified or isolated. However, Creswell (2018) notes that confounding variables can become “quite problematic” in correlational studies (p. 92). To prevent factors that may confound the purpose and objectives of this study, survey responses from students who answered, “primarily on campus, but taking some online courses,” “primarily online, but taking some courses on-campus,” or “I am not sure” were eliminated. Because this study focuses on student perception of social presence in online computer science courses, the experience of social presence in non-online contexts (such as meeting a professor face-to-face) may confound the data. While the social presence construct is focused on text-based interactions for this study, other confounding

variables may include synchronous video interactions (such as Zoom sessions and other video conferencing technologies), which are not specifically disaggregated in the CERP survey data.

Other relevant threats to internal validity include selection bias, maturation, and attrition (Bhandari, 2020; Drost, 2011). Selection bias is irrelevant because of the ex post facto design; there will not be control and experimental groups. Maturation should not be of concern because data from the CERP instrument are collected on a rolling basis. Attrition will not occur because there were no direct participants in this study. The CERP survey is long, with 144 enumerated questions, reasonably fitting the psychometrics criteria, which assumes "all other things being equal, a long test is a good test" (Drost, 2011, p. 113).

Construct validity is how well an instrument measures its intended latent variable (Bhandari, 2022). Because the notion of social presence is problematic in the literature, despite decades of research, aligning specific items on the CERP instrument to subconstructs in social presence theory will lack established construct validity. According to Zumbo and Rupp (2009), "scores of latent variables aligned to constructs of interest within a particular conceptual framework may support validity" (p. 84). While a "rational link" between latent variables of an instrument and the "underlying construct" it is intended to measure can be difficult to establish, it is also acceptable to "alternatively conceive of a latent variable as a mere data processing filter" that "allows for ordered inferences" about cases and items on an instrument (Zumbo & Rupp, 2009, p. 77). Aligning the conceptual framework to items on the CERP survey will allow inferences to be drawn about the proposed constructs and subconstructs, but not claims of direct measurement of the data.

Identifying constructs based on literature reviews and meta-analyses is complex and can often lead to "construct identity fallacies" as well as "jingle-jangle" fallacies (Larsen & Bong, 2016, p. 529). Kreijns et al. (2021) note these threats to construct validity in their proposed conceptual framework concerning measuring social presence. Alignment of the three subconstructs of social presence, sociability, and social space, to items on the CERP instrument within the context of Kreijns et al.'s conceptual framework may enhance, though like any social or behavioural science measurement, not guarantee, construct validity; it may, however, support the reliability of the underlying measures (Zumbo & Rupp, 2009, p. 75).

Consequently, RQ3 seeks to address this threat to construct validity by incorporating a test of internal correlation between the constructs as part of this study. Calculations of Cronbach's

(1951) alpha will also be applied to the specific items from the CERP instrument for each subconstruct and reported as part of testing Hypothesis Three. The closer the reliability coefficient of Cronbach's alpha is to 1, the stronger the internal consistency of the items on the instrument.

4.8 Research Ethics/Ethical Considerations

This study is an ex post facto design based on extant archival data. Typically, archival data require permission from institutional "gatekeepers" (Creswell, 2018, p. 261). The entire dataset is publicly available because the National Science Foundation in the United States publicly funds the CERP Data Buddies project. Researchers who utilise the dataset must acknowledge and cite the CRA and CERP in their studies. An email with a link to download the dataset was sent to the researcher.

There was no direct contact with participants in this study; therefore, participant consent was unnecessary. "Passive consent" constitutes the use of archival data where consent was captured by the primary data collection agency (De Meyrick, 2005). The dataset contains no personally identifiable information of participants. Questions #4-6 of the CERP survey include a link to a consent form, ensuring that the students are adults (age 18 and above) and capturing their consent to participate (CERP Instrument, 2022).

The researcher conducted statistical procedures according to best practices and report the results accurately. This study is carefully delimited in scope. Limitations, both in design and generalisability of results, are acknowledged.

An ethics application was submitted to the Ethics Review Committee (ERC) in the University of South Africa Department of Education in February 2023. After minor revisions, ERC approval was granted on 20 February 2023 (see Appendix A).

4.9 Limitations and Delimitations of the Study

Limitations are potential weaknesses of a research study beyond the researcher's control or this study's design (Theofanidis & Fountouki, 2018; Creswell, 2018). According to Theofanidis and Fountouki (2018), any attempted research study "inevitably carries limitations and delimitations regarding its underlying theories, study design, replication potential" as well as "missing data, causal relationships, measurement errors" and "data collection/analysis" (p. 155). The antidote to limitations in research is to identify them early in the process, disclose

them, and design the study accordingly. When limitations are “neglected, overlooked, or hushed,” the integrity of a study is jeopardised (p. 155). There are three explicit limitations to this study.

Firstly, the major limitation of this study is the contested nature of the definition and measurement of social presence as a construct. A single, validated instrument specifically designed to measure social presence will not be used; rather, a conceptual framework, with operational definitions of the social presence subconstructs, was aligned to instruments on the CERP survey instrument. This approach limits what can be said about the data; while they are aligned to theoretical constructs, they were not originally intended to measure those constructs. The data must be addressed accordingly. As a result, construct validity was tested.

Secondly, while social presence researchers have distinguished between asynchronous and synchronous methods and tools in online learning environments, the CERP instrument does not disaggregate these methods. Instead, the only option is to indicate that the student studied “completely online,” but precisely what methods or tools were used are not disclosed. Ambiguity about the tools or technologies used in the online learning delivery of the courses is an acknowledged limitation, as students who experienced synchronous interactions may, as the literature suggests, have higher satisfaction rates and, in turn, richer perceptions of social presence in the online learning environment (Moallem, 2015). Unfortunately, the dataset for this study is insufficient to aid in examining such distinctions.

Finally, because this study is an ex post facto correlational design, no causal claims can be made about the relationships or associations between variables (Creswell, 2018). This study is inherently limited by its own design in that no specific intervening variables were introduced. Because of this limitation, no causal language was used when reporting the findings. Further, disclosed threats to validity, such as confounding variables, are inherent limitations of this study (Drost, 2011).

Delimitations frame the boundaries of a research study and ensure it is sufficiently narrow in scope (Theofanidis & Fountouki, 2018; Creswell, 2018). The scope of this study is sufficiently narrow insofar as it is focused on a specific target population within an extant dataset, derived from a specific instrument, focused on a specific academic discipline, and further narrowed to include only students who have studied computer science online. These factors delimit this study. While the CERP survey instrument is extensive and the data could be examined

considering various dependent and independent variables, this study is aligned to its problem statement, research aim, research objectives, research questions, and hypotheses.

4.10 Summary

This chapter justified the chosen research methodology and design for this study. The population and sample selection procedures related to the archival data were delineated. As subconstructs of social presence theory, the variables were aligned to specific questions on the CERP instrument. Data collection and data preparation procedures were presented. Data analysis and interpretation procedures for correlational statistical tests were described. Issues of reliability and validity were evaluated. Issues concerning research ethics, including ethical approval, were presented. Finally, the limitations and delimitations of this study were disclosed.

Moreover, this chapter provided a detailed overview of the methodology and design of this study relevant to examining the relationship between student retention in online computer science degree programmes and perceptions of social presence. The procedures delineated in this chapter ensure that the research design and data collection procedures align with the research questions and theoretical framework of social presence theory. This chapter also highlights the importance of maintaining ethical standards and acknowledges the limitations and potential impact on the validity and reliability of the study. In the next chapter, data are analysed, and hypotheses are tested.

Chapter 5 Data Analysis

5.1 Introduction

This chapter reports the data analysis and findings. Data preparation includes procedures for accessing the data from the CRA and importing data into IBM SPSS, eliminating missing data and cleaning the dataset, and devising calculations for the constructs and subconstructs as unique variables. Data analysis includes assumptions tests for constructs and subconstructs, including the Kolmogorov-Smirnov and Shapiro-Wilk tests for normality, a presentation of descriptive statistics, hypothesis testing, and post hoc procedures. Post hoc procedures include an analysis of power and effect size. Finally, reliability and validity are evaluated. Reliability is evaluated using Cronbach's alpha for each social presence composite construct variable subconstruct. Validity is evaluated in terms of construct, content, criterion, and internal and external validity.

5.2 Data Preparation

This section reports the procedures for data collection from the CERP dataset. Data preparation, including cleaning and filtering the dataset, is described. Procedures and formulas for computing variables for the subconstructs of the conceptual framework are explained.

This study utilised publicly available archival data. The CERP dataset was downloaded from the Data Buddies website on 20 February, 2023, in a zip file containing the dataset in an IBM SPSS ".sav" file format. SPSS uses the term "cases" to indicate records in a dataset. The raw dataset contained 13,306 cases. No deviations from the data collection plan occurred.

The original dataset included 1,029 variables related to various questions using different scales and demographic variables, encompassing various factors that may influence an individual's academic and career trajectory in computer science. The dataset included educational background details, such as previous education, academic history with a specific focus on computer science and math courses, and enrolment information. Variables included reasons for matriculation and persistence in a degree programme and perceptions of the degree programme and institution attended. Several variables in the dataset were related to personal attitudes and beliefs about computing. Demographic information such as gender, race/ethnicity, sexual orientation, disability status, marital status, and socio-economic measures were included.

For purposes of this study, the raw dataset was unusable without preparation and cleaning. All variables irrelevant to this study were removed from the raw dataset. Using the SPSS "Save As…" feature, the "Variables" option was selected. By selecting "Drop All," nearly 1,000 variables in the raw dataset were deselected. Then, only 53 variables related to the questions aligned with the conceptual framework were retained. A new dataset file was created and saved.

Data were cleaned to filter out unselected cases using the "Select Cases" feature in SPSS. The following conditional statements were composed to ensure no blank cases for specific variables:

```
~Missing(onlineProg_location) AND
~Missing(satisfaction_compProg) AND
~Missing(leavePrg_howOften) AND
onlineProg_location = 2
```

In SPSS, the tilde represents the logical, NOT operator. The selection filter included only records with no missing values for the two dependent variables and the mediating variable, and whether the student's computer science programme was "Entirely Online," which is indicated by the value "2". Following the application of this selection filter, 2 003 records remained.

5.2.1 Subscale Variable Computation

The variables for this study are based on values derived from questions on the CERP instrument and aligned ex post facto to the conceptual framework. Table 5.1 summarises how variables from the raw datafile were organised according to the conceptual framework's three subconstructs: social presence, sociability, and social space.

Table 5.1 Dataset Variables Organised by Subconstructs

Social Presence	Sociability	Social Space
mentorSupport_perspective	interact_facultyCourse_#	belong_belong
mentorSupport_encourage	interact_facultyNotCourse_#	belong_welcomed
mentorSupport_feedback	interact_classmates_#	support_deptCommunity
identity_compPerson		
identity_bigPart		

The variables from the raw data were based on a five-point scale. However, variables

representing the three subconstructs of the theoretical framework had to be computed. The formulas in Table 5.2 were composed using the "Compute Variable" feature of SPPS. For each subconstruct, the variables were summed and divided by the number of variables, resulting in a mean score on a ratio scale of 1-5.

Table 5.2 Formulas for Computed Variables for Each Subconstruct

Social Presence	Sociability	Social Space
social_presence = (mentorSupport_perspective + mentorSupport_encourage + mentorSupport_feedback + mentorSupport_compassion + identity_compPerson + identity_bigPart) / 6	sociability = (interact_facultyCourse_# + interact_facultyNotCourse_# + interact_classmates_#) / 3	social_space = (belong_belong + belong_welcomed + support_deptCommunity) / 3

The independent variables, persistence and satisfaction, were each derived from single questions from the CERP survey based on five-point scales. The satisfaction variable was usable at its current scale. However, the persistence variable was reverse scored because the question was stated in terms of intent to leave a computer science degree programme rather than to persist. The final persistence variable was calculated by subtracting the existing value from the upper bound value of five plus one.

5.2.2 Composite Variable Computation

A composite social presence variable was computed by summing the values of all the variables constituting each subconstruct and dividing the total by the number of variables. The formula was as follows:

```
( mentorSupport_perspective
+ mentorSupport_encourage
+ mentorSupport_feedback
+ mentorSupport_compassion
+ identity_compPerson
+ identity_bigPart
+ interact_facultyNotCourse_#
+ interact_classmates_#
+ belong_belong
+ belong_welcomed
+ support_deptCommunity
```

) / 12

The computed composite social presence variable was used for testing Hypotheses 1 and 2. Each computed subconstruct variable was used for testing Hypothesis 3 and for reliability analyses (see Table 5.3).

Table 5.3 Dataset Variables Organised by Independent Variables

Satisfaction	Persistence
satisfaction_compProg	leavePrg_howOften
=(satisfaction_compProg)	=(6-leavePrg_howOften)

The data was ready for analysis with the data cleaned and filtered through proper selection and the variables set up for correct computation.

5.4 Data Analysis and Results

This section includes data analysis and the results of hypothesis testing. The results of assumptions tests and descriptive statistics are reported. Statistical procedures were conducted using IBM SPSS. Tables and descriptive summaries were partially generated with software. The results of post hoc procedures are presented. A discussion of reliability and validity, including the results of Cronbach's alpha for each subconstruct, is included. The validity of the results is also evaluated.

5.3.1 Assumptions Tests

Violating assumptions can affect the accuracy and validity of correlation tests (Ellis, 2012). It is important to assess these assumptions before conducting a correlation test and, if necessary, respond appropriately to correct violations. Alternative correlation tests, such as Spearman's rank correlation, are more appropriate when assumptions for Pearson's correlation are unmet.

Pearson's correlation coefficient assumes that the variables being analysed follow a bivariate normal distribution. The variables must have a normal individual distribution, and their joint distribution must also be normal. If the variables do not meet the assumption of normality, Pearson's correlation coefficient may not be appropriate and may not accurately measure the strength and direction of the linear relationship between the variables (Ellis, 2012).

For purposes of this study, the data are independent, and each case's values should not affect the values of the others. Therefore, it is assumed that each computer science student completed the CERP survey independently, and each case is unique and unrelated.

5.3.1.1 Social Presence Subconstruct Assumptions Statistics

For the social presence subconstruct variable, the 5% trimmed mean value, which removed the highest and lowest 5% of values, was slightly lower than the mean value at 2.9548, indicating that extreme values may have a small impact on the mean value. However, the median value for the variable was 3.00, close to the mean value, suggesting that the distribution of values was roughly symmetrical.

The social presence subconstruct variable had a variance of 1.063 and a standard deviation of 1.03086, indicating moderate variability. The minimum value for the variable was 1.00, while the maximum value was 5.00, resulting in a range of 4.00. The interquartile range, which measures the spread of values between the 25th and 75th percentile, was 1.83, indicating moderate variability between the middle 50% of the values (see Table 5.4).

The social presence subconstruct variable had a positive skewness of 0.180, suggesting that the distribution was slightly skewed to the right. The negative kurtosis value of -0.948 suggested that the distribution was relatively flat compared to a normal distribution, with fewer extreme values than expected under a normal distribution (see Figure 5.1).

Table 5.4 Descriptive Statistics for the Social Presence Subconstruct

		Statistic	Std. Error
Mean		2.9686	.02541
95% Confidence Interval for	Lower Bound	2.9188	
Mean	Upper Bound	3.0184	
5% Trimmed Mean		2.9548	
Median		3.0000	
Variance		1.063	
Std. Deviation		1.03086	
Minimum		1.00	
Maximum		5.00	
Range		4.00	
Interquartile Range		1.83	

Skewness	.180	.060
Kurtosis	-.948	.121

Figure 5.1 presents a histogram and box-and-whisker plot of the social presence subconstruct. Note the kurtosis of the histogram.

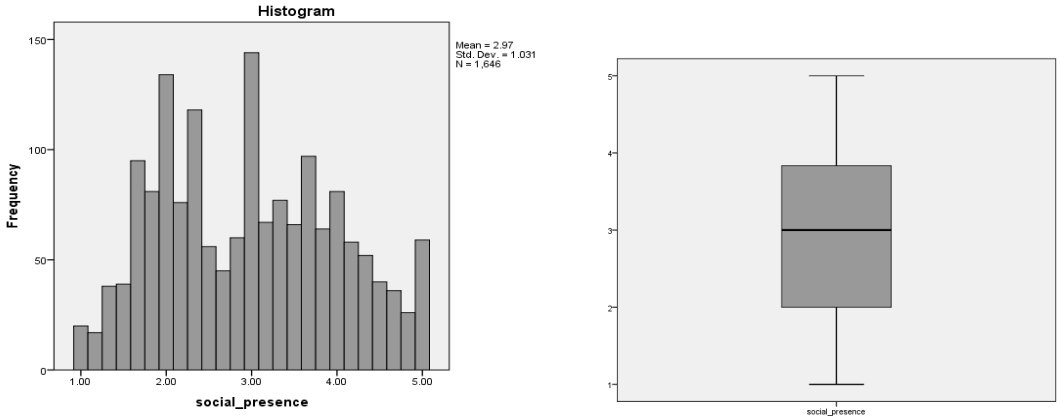

Figure 5.1 Histogram and Box-and-Whisker plot of the Social Presence Subconstruct

The histogram in Figure 5.1 shows a relatively normal distribution with a slight positive skewness. The box-and-whisker plot shows a box slightly skewed to the left, indicating that most of the data were clustered towards the higher end of the scale, with a few outliers towards the lower end. The median was at 3.00, with an interquartile range of 1.83.

5.3.1.2 Sociability Subconstruct Descriptive Statistics

For the sociability subconstruct variable, 5% trimmed mean value, which removed the highest and lowest 5% of values, was slightly lower than the mean value at 2.4984, indicating that the presence of extreme values may have had a small impact on the mean value. The median value for the variable was 2.3333, which was lower than the mean value and suggested that the distribution of values was skewed to the right.

The sociability subconstruct variable had a variance of 0.725 and a standard deviation of 0.85144, indicating moderate variability in the values. The minimum value for the variable was 1.00, the maximum value was 5.00, and the range was 4.00. The interquartile range, which measures the spread of values between the 25th and 75th percentile, was 1.00, indicating moderate variability between the middle 50% of the values (see Table 5.5).

The sociability subconstruct variable had a positive skewness of 0.313, indicating that the distribution was slightly skewed to the right. However, the magnitude of the skewness value (0.313) was relatively small, suggesting that the distribution is only slightly skewed. The kurtosis value of -0.086 indicates that the distribution was relatively flat compared to a normal distribution, with fewer extreme values than would be expected under a normal distribution (see Figure 5.2).

Table 5.5 Descriptive Statistics for the Sociability Subconstruct

		Statistic	Std. Error
Mean		2.5176	.02099
95% Confidence Interval for	2.4765		
Mean	2.5588		
5% Trimmed Mean		2.4984	
Median		2.3333	
Variance		.725	
Std. Deviation		.85144	
Minimum		1.00	
Maximum		5.00	
Range		4.00	
Interquartile Range		1.00	
Skewness		.313	.060
Kurtosis		-.086	.121

Figure 5.2 presents a histogram and box-and-whisker plot of the sociability subconstruct. Note the skewness of the histogram.

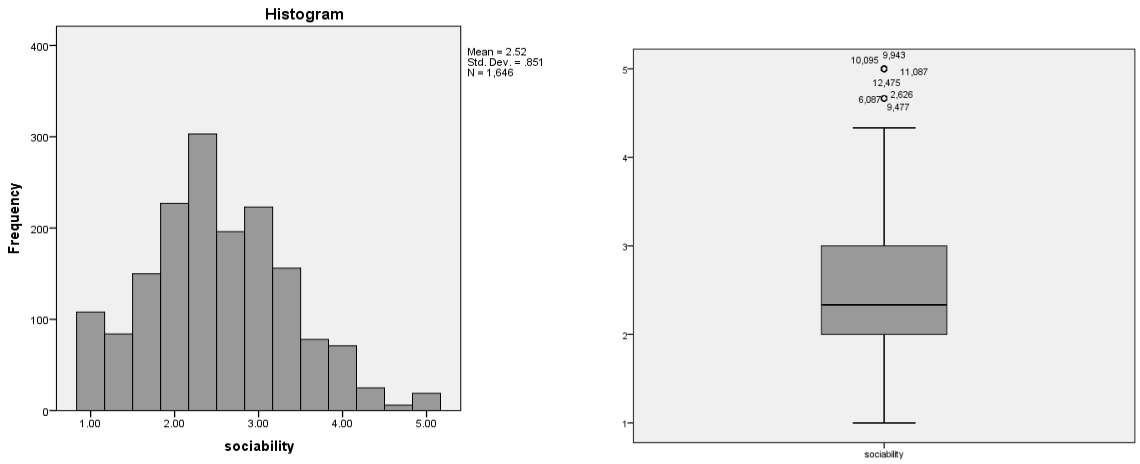

Figure 5.2 Histogram and Box-and-Whisker plot of the Sociability Subconstruct

For the sociability subconstruct variable, the 5% trimmed mean value, which removed the highest and lowest 5% of values, was slightly higher than the mean value at 3.6619, indicating that the presence of extreme values may have had a small impact on the mean value. However, the median value for the variable was 3.6667, close to the mean value, suggesting that the distribution of values was roughly symmetrical (see Table 5.6).

The sociability subconstruct variable had a variance of 0.706 and a standard deviation of 0.84029, indicating moderate variability in the values. The minimum value for the variable was 1.00, the maximum value was 5.00, and the range was 4.00. The interquartile range was 1.33, indicating moderate variability between the middle 50% of the values.

Table 5.6 Descriptive Statistics for the Social Space Subconstruct

		Statistic	Std. Error
Mean		3.6304	.02071
95% Confidence Interval for	3.5898		
Mean	3.6710		
5% Trimmed Mean		3.6619	
Median		3.6667	
Variance		.706	
Std. Deviation		.84029	
Minimum		1.00	
Maximum		5.00	
Range		4.00	

Interquartile Range	1.33	
Skewness	-.424	.060
Kurtosis	-.057	.121

The sociability subconstruct variable had a negative skewness of -0.424, indicating that the distribution was slightly skewed to the left. However, the magnitude of the skewness value (-0.424) was relatively small, suggesting that the distribution was only slightly skewed. The kurtosis value of -0.057 indicated that the distribution was relatively flat compared to a normal distribution, with fewer extreme values than would be expected under a normal distribution. Figure 5.3 presents a histogram and box-and-whisker plot of the sociability subconstruct.

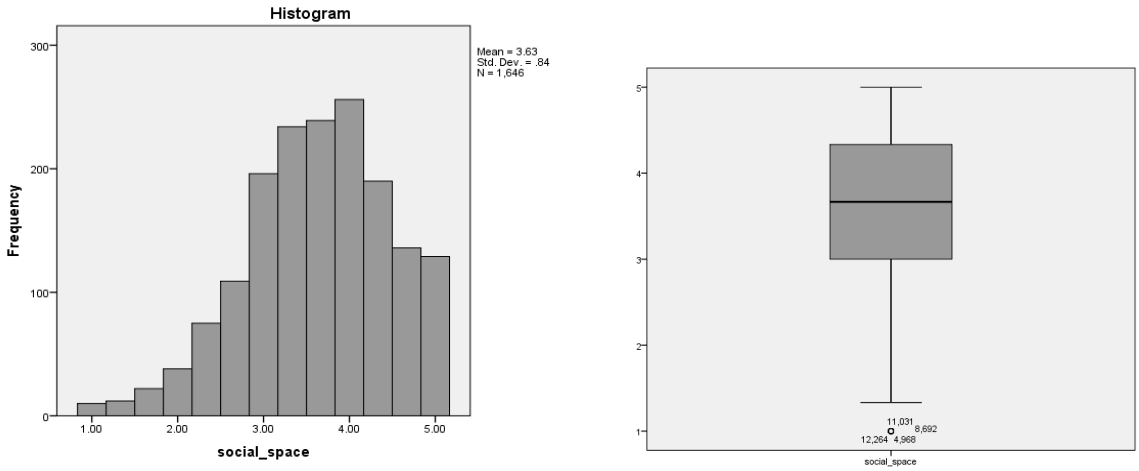

Figure 5.3 Histogram and Box-and-Whisker plot of the Social Space Subconstruct

The skewness of the histogram for the social space subconstruct was negative (-0.424), indicating that the distribution is slightly skewed to the left, with a longer tail to the left and more scores to the right of the mean. This visualisation suggests that most cases scored high in social space, with a few outliers having very low scores.

5.3.1.3 Social Presence Composite Construct Assumptions Statistics

For the social presence composite construct variable, the 5% trimmed mean value, which removed the highest and lowest 5% of values, was very similar to the mean value at 2.8114, indicating that the presence of extreme values had negligible impact on the mean value. The median value for the variable was 2.7500, which was slightly lower than the mean value and suggested that the distribution of values was slightly skewed to the right (see Table 5.7).

The social presence composite construct variable had a variance of 0.472 and a standard deviation of 0.68738, indicating moderate variability in the values. The minimum value for the variable was 0.92, the maximum value was 4.58, and the range was of 3.67. The interquartile range was 1.00, indicating moderate variability between the middle 50% of the values.

Table 5.7 Descriptive Statistics for the Social Presence Composite Construct

		Statistic	Std. Error
Mean		2.8134	.01694
95% Confidence Interval for Mean	2.7802		
	2.8467		
5% Trimmed Mean		2.8114	
Median		2.7500	
Variance		.472	
Std. Deviation		.68738	
Minimum		.92	
Maximum		4.58	
Range		3.67	
Interquartile Range		1.00	
Skewness		.085	.060
Kurtosis		-.399	.121

The social presence composite construct variable had a positive skewness of 0.085, indicating that the distribution was slightly skewed to the right. However, the magnitude of the skewness value (0.085) was relatively small, suggesting that the distribution is only slightly skewed. The kurtosis value of -0.399 indicated that the distribution was relatively flat compared to a normal distribution, with fewer extreme values than would be expected under a normal distribution.

Figure 5.4 presents a histogram and box-and-whisker plot of the social presence composite construct. Note the relatively uniform distribution of the histogram and centredness of the box-and-whisker plot.

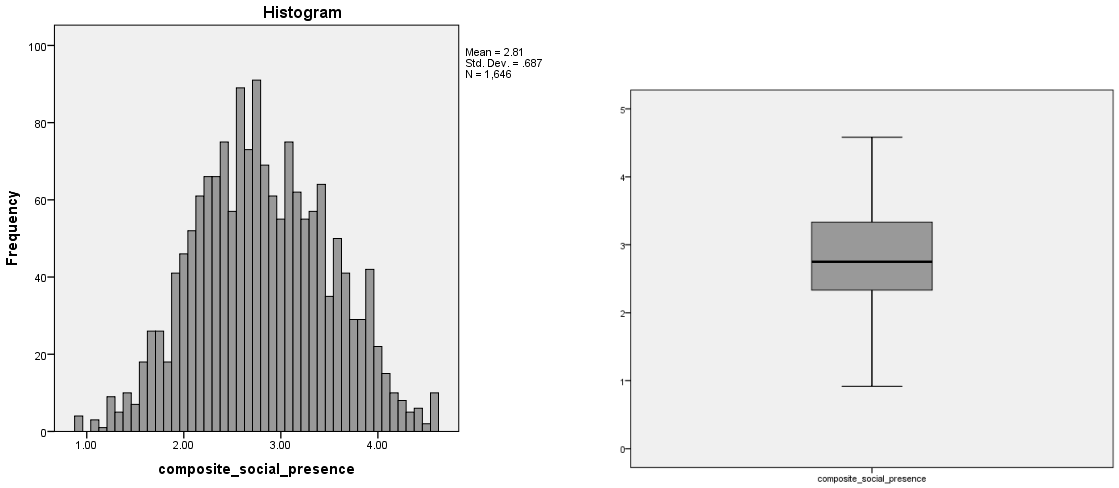

Figure 5.4 Histogram and Box-and-Whisker plot of the Social Presence Subconstruct

The skewness of the histogram for the social presence composite construct was close to zero (0.085), indicating that the distribution was approximately symmetrical with most of the cases scored about the mean. This visualisation suggests that the data had relatively few outliers and that the cases were more evenly distributed than the social space subconstruct.

5.3.1.4 Kolmogorov-Smirnov and Shapiro-Wilk Normality Tests

Specific tests can be conducted on the data to determine normality measures (Khatun, 2021). The Pearson procedure assumes that variables follow a bivariate normal distribution. Normality means that the variables have a normal individual distribution, and their joint distribution is also normal (Ellis, 2012). SPSS can conduct both tests.

The Kolmogorov-Smirnov test calculates the maximum difference between the observed and the expected cumulative distribution functions (Hanusz & Tarasińska, 2015; Dodge, 2008; Massey, 1951), while the Shapiro-Wilk test tests the null hypothesis that the sample data was drawn from a normal distribution (Hanusz & Tarasińska, 2015; Shapiro & Wilk, 1965). Both tests are commonly used to test normality assumptions in statistical analyses.

Normality tests were conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests for social presence, sociability, social space, and composite social presence. The results of the normality tests are reported in Table 5.8.

Table 5.8 Results of the Kolmogorov-Smirnov and Shapiro-Wilk Normality Tests

	Kolmogorov-Smirnov[a]	Shapiro-Wilk

	Statistic	df	Sig.	Statistic	df	Sig.
social_presence	.107	1646	.000	.968	1646	.000
sociability	.115	1646	.000	.972	1646	.000
social_space	.102	1646	.000	.966	1646	.000
composite_social_presence	.050	1646	.000	.995	1646	.000

a. Lilliefors Significance Correction

For all four variables, both tests resulted in a significant p-value (< 0.05), indicating that the distributions of values for the variables are significantly different from normal. The assumption of normality is not always strictly necessary for Pearson's correlation coefficient to be useful, especially when the sample size is large. The sample size was relatively large in this study. However, given the strength of the probability values calculated in the Kolmogorov-Smirnov and Shapiro-Wilk Normality Tests, it was deemed necessary to revert to a non-parametric procedure that does not assume normality. The Spearman rank correlation procedure was selected.

5.3.2 Descriptive Statistics

Descriptive statistics provide valuable information about the central tendency, variability, and shape of the distribution of values for the construct and subconstruct variables being analysed (see Table 5.9). Basic descriptive statistics for each subconstruct of composite social presence are described. The descriptive tables and some of the descriptive narratives were partially software-generated.

Table 5.9 Descriptive Statistics for Each Subconstruct and Subconstruct

	N	Sum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
persistence	2003	8244.00	4.1158	1.03513	1.071	-1.031	.055	.357	.109
satisfaction	2003	7838.00	3.9131	1.02537	1.051	-1.058	.055	.746	.109
composite_social_presence	1652	4646.00	2.8123	.68757	.473	.081	.060	-.391	.120
social_presence	1669	4953.00	2.9676	1.03128	1.064	.173	.060	-.950	.120
sociability	1970	4982.33	2.5291	.85358	.729	.302	.055	-.100	.110
social_space	1758	6371.33	3.6242	.84195	.709	-.439	.058	-.019	.117
Valid N (listwise)	1646								

The first subconstruct variable, social presence, had an average value of 2.9686, below the midpoint of its range. However, based on the 95% confidence interval for the mean value, which is between 2.9188 and 3.0184, it is likely that the true population mean value falls within this range with 95% confidence. The second subconstruct variable, sociability, had an average value of 2.5176, which also fell below the midpoint of its range. However, the 95% confidence interval for the mean value was between 2.4765 and 2.5588, indicating that the true population mean value was likely to fall within this range with 95% confidence. Finally, the third subconstruct variable, also sociability, had an average value of 3.6304 (the highest of the three), above the midpoint of its range. However, the 95% confidence interval for the mean value for sociability was between 3.5898 and 3.6710, which suggests that the true population mean value was likely to fall within this range with 95% confidence. Lastly, the composite construct variable for social presence had an average value of 2.8134, which was slightly below the midpoint of its range. However, its 95% confidence interval for the mean value was between 2.7802 and 2.8467, indicating that the true population mean value was likely to fall within this range with 95% confidence.

5.3.3 Descriptive Demographic Statistics

This section presents the demographic data derived from the CERP dataset, including only students who studied computer science entirely online. Descriptive statistics about why students chose to study online and racial, sexual orientation, gender, and age demographics are presented.

Table 5.10 shows the cases in the dataset for students who enrolled in an online computer science degree programme and their reasons for doing so. The most common reason for enrolling in an online programme was that the programme of interest was only available online, which accounted for 34% of the cases. The second most common reason was not wanting to relocate and/or commute, which accounted for 18% of the cases. Other reasons included wanting to take courses at their own pace (14%), having a job and wanting to continue working while getting an education (11%), online programmes having lower costs (9%), and having family responsibilities (9%). A small percentage of students (6%) did not select any given reasons. A substantial number of cases were left “unselected” for each item.

Table 5.10 Cases for the Question “Why did you enrol in an online program?”

	Frequency	Percent	Unselected
The programme I was interested in was only available online	842	34%	1154

I did not want to relocate and/or commute	443	18%	1553
I wanted to take course at my own pace	338	14%	1658
I have a job and I wanted to continue working while getting an education	280	11%	1716
Online programs have lower costs	213	9%	1783
I have family responsibilities	220	9%	1776
None of the above	141	6%	1855

There were eight race-related demographic variables in the dataset, with the number of cases ranging from 11 to 730. The "Race: White" variable had the highest number of cases, totalling 730 (48%). Asian cases were the second largest racial demographic represented in the dataset, with 598 cases (40%). Together, these two racial categories accounted for 88% of the cases. The "What is your age?" variable had 2,003 cases with a mean of 21.23, a standard deviation of 4.618, and a variance of 21.330. The "Valid N (listwise)" variable had a count of 1365, indicating the number of cases with complete data for all variables (see Table 5.11).

Table 5.11 Demographic Descriptive Statistics for Student Race

	N	Sum	Mean	Std. Deviation	Variance
Race: Arab	1507	48	.03	.176	.031
Race: Asian	1507	598	.3968	.48940	.240
Race: Black	1507	151	.10	.300	.090
Race: Indigenous	1507	14	.01	.096	.009
Race: Native	1507	26	.02	.130	.017
Race: Pacific Islander	1507	11	.01	.085	.007
Race: White	1507	730	.48	.500	.250
Race: Other	1507	76	.05	.219	.048
What is your age?	2003	-	21.23	4.618	21.330
Valid N (listwise)	1365				

Table 5.12 shows the sexual orientation variable cases from the dataset. From a total of 2,003 cases, 75.3% (1236) identified as heterosexual, 3.0% (61) identified as homosexual, 6.9% (138) identified as bisexual, 2.2% (45) identified as something else, and 1.4% (28) identified as asexual. The cumulative percent is also shown, with 82.0% of cases identifying as heterosexual, 86.0% identifying as heterosexual or homosexual, 95.2% identifying as heterosexual, homosexual, or bisexual, and 100% identifying as one of the five categories provided. A separate question in the dataset asked, "Are you transgender?" which had 1555 cases, all of which were "no." The total number of missing cases was 495 (24.7%). The data suggest that most cases identified as heterosexual, with smaller proportions identifying as homosexual,

bisexual, something else, or asexual. There were also missing values, with 76 cases not consisting of a valid response (-99) and 419 cases categorised as “System” (20.9%).

Table 5.12 Demographic Descriptive Statistics for Student Sexual Orientation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Heterosexual	1236	61.7	82.0	82.0
	Homosexual	61	3.0	4.0	86.0
	Bisexual	138	6.9	9.2	95.2
	Something else	45	2.2	3.0	98.1
	Asexual	28	1.4	1.9	100.0
	Total	1508	75.3	100.0	
Missing	-99	76	3.8		
	System	419	20.9		
	Total	495	24.7		
Total		2003	100.0		

Table 5.13 includes descriptive statistics about the genders of cases in the dataset. The sample consisted of 2003 cases, of which 77.3% (1548) had valid data. Among these valid cases, 23.7% (475) identified as women, 52.1% (1044) identified as men, and 1.4% (29) identified as non-binary. The cumulative percent is included, with 100% identifying as one of the three supplied categories. There were also missing values, with 22.7% (455) of cases categorised as “System.” The data suggests that most cases identified as men, with a smaller proportion identifying as women or non-binary. However, the number of missing cases could limit the generalisability of the findings.

Table 5.13 Demographic Descriptive Statistics for Student Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Woman	475	23.7	30.7	30.7
	Man	1044	52.1	67.4	98.1
	Non-binary	29	1.4	1.9	100.0
	Total	1548	77.3	100.0	
Missing	System	455	22.7		
Total		2003	100.0		

Concerning reported age demographics, most cases were between 18 and 21, accounting for 53.8% of the total cases. Cases aged 22 to 25 accounted for 8.5%, while those aged 26 to 29 accounted for 3.0% of the total cases. The proportion of cases decreased as age increased, with only 0.2% of students aged 50 or over. The average age of the cases was about 20 years old.

5.3.4 Hypothesis Testing

The three hypotheses were tested independently using SPSS. Based on the cumulative results of the assumptions tests, it was determined that a nonparametric procedure would be most appropriate for the data. Although the constructs had only minor skewness and kurtosis and histograms appeared relatively bell-shaped (especially the social presence composite construct), the Kolmogorov-Smirnov and Shapiro-Wilk Normality tests all returned p values < .05, indicating distributions of values for the variables were significantly different from normal. Therefore, the Spearman rank procedure was selected as the most prudent for this study.

Like Pearson's Product Moment of Correlation, Spearman's Rank Correlation Coefficient is a nonparametric statistical procedure used to evaluate the strength and direction of a relationship between two variables, where both variables are in the form of rankings or ordinal data. Spearman's rank measures the degree of association between the two variables and ranges from -1 to 1, where -1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. Spearman's Rank is calculated by assigning ranks to each variable and then calculating the difference between the ranks. The correlation coefficient from a Spearman Rank procedure is an "r" (rho) value.

Pearson's procedure was also applied to each hypothesis for posterity, and the results did not change substantially.

5.3.4a Hypothesis 1

Spearman's rank correlation procedure was used to analyse the relationship between the two variables, social presence scores and persistence ratings. The sample size for both variables is quite large, with 1,652 cases for composite social presence and 2,003 cases for persistence. The sample size for the analysis was 1,652 for the social presence composite construct and student persistence. Null Hypothesis 1 was:

$H_0$1: No statistically significant relationship exists between composite social presence scores and persistence ratings among students who studied computer science online, according to aligned items on the CERP instrument (see Table 5.14).

Table 5.14 Spearman's Correlation for Hypothesis 1

			composite_social_presence	Persistence
Spearman's rho	composite_social_presence	Correlation Coefficient	1.000	.293**
		Sig. (2-tailed)	.	.000
		N	1652	1652
	Persistence	Correlation Coefficient	.293**	1.000
		Sig. (2-tailed)	.000	.
		N	1652	2003

**. Correlation is significant at the 0.01 level (2-tailed).

The analysis results suggest a significant positive correlation between composite social presence and persistence, as indicated by Spearman's rho ($r = 0.293$, $p<0.01$). The correlation coefficient between the social presence composite construct and student persistence was 0.293. The correlation between the social presence composite construct and student persistence was statistically significant ($p<0.01$).

The null hypothesis was rejected.

Figure 5.5 is a scatterplot chart illustrating the relationship between mean student persistence scores and composite social presence scores. Again, note the relatively clear linear relationship.

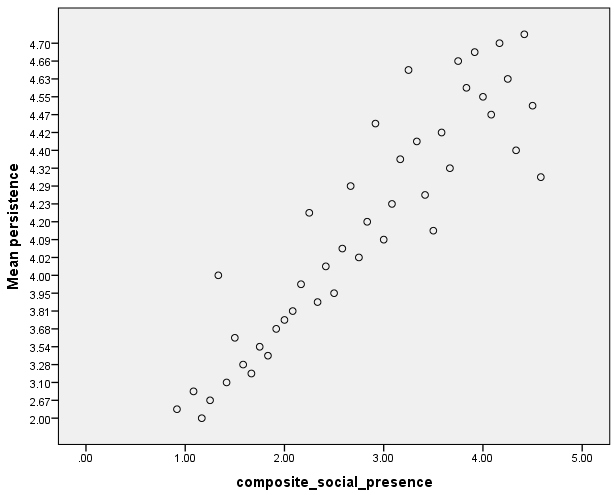

Figure 5.5 Scatterplot of Mean Student Persistence and Composite Social Presence

The scatterplot chart for these data illustrates a positive linear relationship between composite social presence and persistence. As the composite social presence score increases, the persistence score also tends to increase. The correlation coefficient of 0.293** indicates a

moderately positive correlation between the two variables, which is statistically significant at the 0.01 level. However, correlation does not necessarily imply causation. Composite social presence is not the sole factor influencing persistence.

5.3.4b Hypothesis 2

Spearman's rank correlation procedure was used to analyse the relationship between the two variables, social presence composite construct scores and student satisfaction ratings. The sample size for the analysis was 1,652 for the social presence composite construct and 2,003 for student satisfaction. Null Hypothesis 2 was:

$H_0$2: No statistically significant relationship exists between composite social presence scores and student satisfaction ratings among students who studied computer science online according to aligned items on the CERP instrument (see Table 5.15).

Table 5.15 Spearman's Correlation for Hypothesis 2

			satisfaction	composite_social_presence
Spearman's rho	Satisfaction	Correlation Coefficient	1.000	.280**
		Sig. (2-tailed)	.	.000
		N	2003	1652
	composite_social_presence	Correlation Coefficient	.280**	1.000
		Sig. (2-tailed)	.000	.
		N	1652	1652

**. Correlation is significant at the 0.01 level (2-tailed).

The results suggest a statistically significant positive correlation between satisfaction and composite social presence ($r = .280$, $p < .01$). The composite social presence and satisfaction correlation coefficient was also significant at the 0.01 level ($r = .280$, $p < .01$), with a similar correlation strength (see Table 5.15). These findings were based on data from 2,003 cases for satisfaction and 1,652 for composite social presence.

The null hypothesis was rejected.

5.3.4c Hypothesis 3

Spearman's rank correlation procedure was used to analyse the relationship between the two variables, social presence composite construct scores and student persistence ratings (see Table 21). Null Hypothesis 3 was:

$H_0$3: No statistically significant relationship exists between the subconstructs of social presence, sociability, and social space among perceptions of students who studied computer science online according to aligned items on the CERP instrument (see Table 5.16).

Table 5.16 Spearman's Correlation Matrix for Hypothesis 3

			social_presence	sociability	social_space
Spearman's rho	social_presence	Correlation Coefficient	1.000	.202**	.429**
		Sig. (2-tailed)	.	.000	.000
		N	1669	1655	1660
	sociability	Correlation Coefficient	.202**	1.000	.139**
		Sig. (2-tailed)	.000	.	.000
		N	1655	1970	1741
	social_space	Correlation Coefficient	.429**	.139**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	1660	1741	1758

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation matrix suggests statistically significant correlations between all three variables: social presence subconstruct, sociability subconstruct, and sociability subconstruct.

The social presence subconstruct was positively correlated with the sociability subconstruct, with a correlation coefficient of 0.202, which is statistically significant at a 2-tailed significance level of < 0.01 beyond several decimal places.

The social presence subconstruct was also positively correlated with the sociability subconstruct, with a correlation coefficient of 0.429, statistically significant at a 2-tailed significance level of < 0.01 beyond several decimal places.

Finally, the sociability subconstruct was positively correlated with the sociability subconstruct, with a correlation coefficient of 0.139, statistically significant at a 2-tailed significance level of < 0.01 beyond several decimal places. Although all three correlations were statistically significant, the strength of the relationships between the variables was only moderate.

The null hypothesis was rejected.

5.3.5 Post Hoc Procedures

Post hoc procedures were applied to the constructs to determine power and effect size. The calculated Spearman's r value for the first two hypotheses indicated a moderate positive

correlation between the variables. Pearson is a correlation of a linear relationship, while Spearman is a correlation for a monotonic relationship. Cohen's d guidelines were used to interpret the effect size of each correlation coefficient after each Spearman's rank correlation coefficient was converted into z-scores using Fisher's transformation. Cliff's delta was also used to measure effect sizes. Univariate analyses examined statistical power and partial eta-squared calculations.

5.3.5.1 Effect Size

Post hoc procedures were conducted to examine the relationship between the variables and to measure the effect size of the correlations. The most common measure of effect size for correlation coefficients is Cohen's d. Cohen's (1988) guidelines for interpreting the effect size of a correlation coefficient suggest that a coefficient of .20 can be considered a small effect, .50 a medium effect, and .80 a large effect. However, using Cohen's d to interpret a correlation coefficient is not typically appropriate. Cohen's d measures effect size for differences between means, whereas a correlation coefficient measures the strength and direction of the relationship between two variables. The two measures are not comparable (Ellis, 2012).

Therefore, Cohen's d is not directly applicable to rank correlation coefficients because the correlation coefficient does not have a defined variance. While Cohen's d can be a useful measure of effect size, it is not always the most appropriate measure, particularly for non-normal data (Rea & Parker, 2014). An alternative is to convert the correlation coefficient into a z-score using Fisher's transformation (Ellis, 2012). Fisher's transformation converts the correlation coefficient into a z-score with a defined variance, which can then be used to calculate Cohen's d. Upon calculation of a z-score, Cohen's d was calculated using the formula $d = \frac{z'}{\sqrt{n}}$, where n is the sample size. Table 5.17 delineates the computed d values based on the Spearman rho values and calculated Fisher's z' transformation scores:

Table 5.17 Fisher's z, Cohen's d, and Cliff's |d| calculations for Hypotheses 1 & 2

	Spearman's rho	Fisher's z'	n	Cohen's d	Cliff's |d|
Hypothesis 1	0.293	0.1707	1,652	0.0042	0.0150
Hypothesis 2	0.280	0.1534	1,652	0.0038	0.0390

Cliff's delta (1993) can also measure effect size on non-parametric tests. Cliff's delta determines the magnitude and direction of the difference between the two groups being compared. Cliff's delta ranges from -1 to 1 and larger values indicate a greater difference between the groups. A value of 0 indicates no difference between the groups.

Therefore, Fisher's z-transformations, converted Cohen's d values, and Cliff's delta for the social presence, sociability, and sociability subconstruct variables are delineated in Table 5.18.

Table 5.18 Fisher's z, Cohen's d, and Cliff's |d| calculations for Hypothesis 3

Variable	Fisher's z-transformation	Cohen's d	Cliff's |d|
social_presence	< 0.001	< 0.001	0.0678
sociability	0.215	0.0053	0.0405
social_space	0.546	0.0133	0.0964

5.3.5.2 Power and Between-Subjects Effects

Power is the probability of rejecting the null hypothesis when it is false or distinguishing an actual effect from random chance (Ellis, 2012). Univariate analyses were applied using SPSS for Hypotheses 1 and 2 to examine statistical power and the partial eta squared calculation for additional evaluation of effect size. The composite social presence construct variable was used as the independent variable in each case. The student persistence and satisfaction construct variables were also used as the dependent variables for each hypothesis respectively (see Table 5.19).

Table 5.19 Power and Effect Size Calculations for Hypothesis 1

Dependent Variable: persistence

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	165.920[a]	1	165.920	172.737	.000	.095	172.737	1.000
Intercept	744.109	1	744.109	774.679	.000	.319	774.679	1.000
composite_social_presence	165.920	1	165.920	172.737	.000	.095	172.737	1.000
Error	1584.888	1650	.961					

Total	29840.000	1652
Corrected Total	1750.809	1651

a. R Squared = .095 (Adjusted R Squared = .094)

b. Computed using alpha = .05

The effect size was moderate for the variable persistence, with a partial eta squared of .095, indicating that 9.5% of the variance in the dependent variable, student persistence, was explained by the independent variable, composite social presence. When controlling for other variables, the adjusted r-squared value of .094 suggests that the independent variable accounts for 9.4% of the variance in the dependent variable. The F-value of 172.737 was significant at $p < .001$, suggesting that the relationship between the two variables was most likely not due to chance. The observed power of 1.000 indicates that the sample size was large enough to detect the observed effect size. The power to detect a significant effect at the alpha level of .05 was very high, indicating that the sample size was likely sufficient to detect the reported effects with reasonable confidence (see Table 5.20).

Table 5.20 Power and Effect Size Calculations for Hypothesis 2

Dependent Variable: satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	128.128[a]	1	128.128	135.321	.000	.076	135.321	1.000
Intercept	731.322	1	731.322	772.378	.000	.319	772.378	1.000
composite_social_presence	128.128	1	128.128	135.321	.000	.076	135.321	1.000
Error	1562.293	1650	.947					
Total	27360.000	1652						
Corrected Total	1690.421	1651						

a. R Squared = .076 (Adjusted R Squared = .075)

b. Computed using alpha = .05

The results of the univariate analysis for the student satisfaction construct variable were similar to those of the student persistence construct variable. The effective size for the analysis was a partial eta squared of .076, indicating a small effect size. The power to detect a significant effect at the alpha level of .05 was very high, with an observed power of 1.0, indicating that the sample sizes were likely sufficient to detect the reported effects with a reasonable confidence level.

5.3.5.3 Summary of Post Hoc Procedures

The strength of the effect size and power varied for different analyses and hypotheses in this study. For the first two hypotheses, Spearman's rho correlation coefficients indicated a moderate positive correlation between the variables, with effect sizes calculated using Cohen's d. The effect sizes were small (d = 0.0042) and very small (d = 0.0038) for Hypotheses 1 and 2, respectively. Fisher's z-transformations converted Cohen's d values, and Cliff's delta was used for the third hypothesis to measure the effect size for each subconstruct variable. The effect sizes were very small for social presence (d < 0.001), small for sociability (d = 0.0053), and medium for social space (d = 0.0133). Univariate analyses examining statistical power and the partial eta squared calculation were conducted. The effect size for student persistence and student satisfaction was moderate, with a partial eta squared of 0.095 and 0.076, respectively.

Power and effect size must be considered in tandem. The sample size was large enough to detect the observed effect size with a computed power of 1.000. However, the effect sizes reported in this study were generally small to very small, with only one variable (student persistence) suggesting a moderate effect size.

5.4 Reliability and Validity

In this section, the results of reliability tests are presented, and validity is evaluated. Cronbach's alpha was applied to each subconstruct and the composite construct of social presence to evaluate internal reliability. Cronbach's (1951) alpha measures the internal consistency of a set of measures. Cronbach's alpha is "the average correlation among all possible pairs of items, adjusting for the number of items" (Hanover College, 2016). Like a correlation coefficient, Cronbach's yields a value ranging from 0 to 1. Values closer to 1 indicate higher reliability. Ideally, measures should have an alpha score greater than 0.7 to indicate strong internal consistency. Cronbach's alpha was computed in SPSS using the Reliability Analysis feature. Variables for each subconstruct and the composite construct were selected for the analysis of each measure. The next subsections present the reliability findings for each subconstruct and the composite social presence construct.

5.4.1 Social Presence Subconstruct

The social presence subconstruct was tested for internal consistency. A total of 2003 cases were considered for the analysis. 1669 cases were included, and 334 cases were excluded (see Tables 5.21 and 5.22).

Table 5.21 Case Processing Summary for Social Presence Subconstruct

		N	%
Cases	Valid	1669	83.3
	Excluded [a]	334	16.7
	Total	2003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 5.22 Reliability Statistics for Social Presence Subconstruct

Cronbach's Alpha	N of Items
.853	6

Based on the computed Cronbach's alpha of .853, the social presence subconstruct can be considered internally consistent and highly reliable.

5.4.2 Sociability Subconstruct

The sociability subconstruct was tested for internal consistency. A total of 2003 cases were considered for the analysis. 1970 cases were included, and 33 cases were excluded (see Tables 5.23 and 5.24).

Table 5.23 Case Processing Summary for Sociability Subconstruct

		N	%
Cases	Valid	1970	98.4
	Excluded [a]	33	1.6
	Total	2003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 5.24 Reliability Statistics for Sociability Subconstruct

Cronbach's Alpha	N of Items
.540	3

Based on the computed Cronbach's alpha of .540, the sociability subconstruct can be considered minimally internally consistent and moderately reliable.

5.4.3 Social Space Subconstruct

The sociability subconstruct was tested for internal consistency. A total of 2003 cases were considered for the analysis. 1758 cases were included, and 245 cases were excluded (see Tables 5.25 and 5.26).

Table 5.25 Case Processing Summary for Social Space Subconstruct

		N	%
Cases	Valid	1758	87.8
	Excluded [a]	245	12.2
	Total	2003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 5.26 Reliability Statistics for Social Space Subconstruct

Cronbach's Alpha	N of Items
.700	3

Based on the computed Cronbach's alpha of .700, the sociability subconstruct can be considered internally consistent and highly reliable.

5.4.4 Social Presence Construct

Finally, the social presence construct, which comprised all variables constituting the three subconstructs, was tested for internal consistency. A total of 2003 cases were considered for the analysis. 1646 cases were included, and 357 cases were excluded (see Tables 5.27 and 5.28).

Table 5.27 Case Processing Summary for Social Presence Construct

		N	%
Cases	Valid	1646	82.2
	Excluded [a]	357	17.8
	Total	2003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 5.28 Reliability Statistics for Social Presence Construct

Cronbach's Alpha	N of Items

.817	12

Based on the computed Cronbach's alpha of .817, the social presence construct can be considered internally consistent and highly reliable.

5.4.5 Validity

This section evaluates this study's construct, content, criterion, and internal and external validity. Because this study used archival data from a national survey with a relatively large sample size, it has defensible external validity. However, because the CERP survey is not a psychometric instrument and has not been validated on its own merits, this study's validity is thereby diminished (DeVellis, 2016).

This study's construct validity is rooted in the fact that the measures used to assess the construct and subconstruct variables were based on a well-established, though not psychometrically validated, survey instrument designed to measure student attrition and retention in computing programmes (DeVellis, 2016). The constructs and subconstructs also align with the conceptual framework and research questions. The composite construct of social presence is based on three interrelated and irreducible subconstructs. However, it should be noted that single questions were used for the student persistence and student satisfaction constructs, respectively. In contrast, multiple questions were used for the social presence construct and related subconstructs. Multiple questions with multiple data points may have strengthened the construct validity of these measures.

Content validity is also defensible for the same reasons: they were chosen based on their alignment with this study's conceptual framework, research questions, and the CERP survey instrument. The specific questions used to assess student satisfaction and persistence are also clearly related to the measured constructs. Original questions were not created for this study. Only extant data from the CERP Data Buddies dataset were analysed ex post facto, meaning the instrument was unmodified.

This study did not explicitly include an assessment of criterion validity, which is the degree to which the construct and subconstruct variables are related to other criteria that would be expected to be associated with the measured constructs. The selection of which questions from the CERP survey best aligned to the constructs of the conceptual framework was somewhat arbitrary, though informed by the literature review. For example, the need to reverse score the

student persistence question may have weakened criterion validity. However, the measures used in this study are based on a well-established survey instrument, which has been utilised in other relevant studies (Lewis et al., 2021; Wright, 2019).

Correlational research has an advantage in terms of external validity compared to experimental research. Internal validity is often higher in experimental studies, but external validity is often lower than in correlational studies (Rea & Parker, 2014). Correlational studies have lower internal validity because variables are neither manipulated nor controlled. However, correlational studies have more external validity because, with less control, they are more likely to reflect real-world relationships between phenomena (Price, Jhangiani, Chiang & Cutler, 2013).

A correlational study has reasonable internal validity because the construct and subconstruct variables are based on a standardised survey instrument. Furthermore, statistical analyses were applied to test for relationships between the variables while at least excluding, though not eliminating, potential confounding variables (Bhandari, 2022; Drost, 2011). Nevertheless, the survey and the data are publicly available, which makes this study easily replicable.

External validity, which refers to the degree to which the findings can be generalised to other populations or settings, may be limited as this study was conducted in a specific context, i.e., students in undergraduate computing programmes in the United States who are CRA members and who completed the CERP survey. However, using such a well-established survey instrument implemented across many higher education institutions in the United States may enhance the external validity of this study's findings.

5.5 Summary

In conclusion, this chapter outlined the data collection, preparation, and analysis procedures. The data collection and preparation process involved accessing the data from the CRA, importing it into IBM SPSS, cleaning and eliminating missing data, and devising calculations for the constructs and subconstructs as unique variables.

Data analysis was conducted by testing assumptions for constructs and subconstructs, including normality tests such as the Kolmogorov-Smirnov and Shapiro-Wilk tests, presenting descriptive statistics, performing hypothesis testing, and post hoc procedures. Unfortunately, the data did not meet the assumptions for parametric procedures. Therefore, Pearson's Product

Moment of Correlation procedure was abandoned, and the Spearman rank procedure was used to test the hypotheses. All three null hypotheses were rejected.

The post hoc procedures included an analysis of power and effect size. Only minor to moderate effects were identified, but the power of the data was strong due to the large sample size. The chapter ended by evaluating reliability and validity, with Cronbach's alpha used to evaluate reliability for each subconstruct of the social presence composite construct variable. The subconstructs were found to be moderate to strongly reliable. Furthermore, construct, content, criterion, internal, and external validity were assessed. Although the validity of this study was largely defensible, several weaknesses in construct and criterion validity were acknowledged.

Chapter 6 Discussion and Implications

6.1 Introduction

This study was significant because it sought to address two interrelated objectives: firstly, to specifically examine perceptions of social presence (and how it relates to persistence and satisfaction) among students who have studied computer science online, and secondly, to contribute research to the body of literature seeking to validate measures of the social presence construct. Because issues surrounding student attrition are complex, more research is required. Nonetheless, this study's objectives were attained.

This chapter discusses the findings and answers to each research question. Limitations of this study are acknowledged. The findings are briefly interpreted in relation to the literature review. Implications are discussed, including implications for general online learning and computer science degree programmes. Recommendations regarding best practices in online teaching and learning are presented, such as feedback as social presence, a sense of community as social space, and instructional design as sociability. Recommendations for future research and a summary conclude this study.

6.2 Discussion of Findings

All three null hypotheses of this study were rejected. Because all three calculated p-values were less than .01, the correlation coefficient was statistically significant, indicating that the correlation was unlikely to have occurred by chance (Ellis, 2012). Because the correlation coefficient was only moderate in each case, the findings also suggest that the relationship between the variables was not particularly strong. Statistical significance does not necessarily imply a causal link. Effect size should also be considered when interpreting results.

For each research question, correlation coefficients for hypotheses were considered in the context of the specific variables. For example, according to Cohen's guidelines, a moderate correlation may be meaningful and significant for certain variables and research questions, even if the effect size is not large (Rea & Parker, 2014). Findings related to each research question and hypothesis are considered contextually on their own terms in the subsections below.

6.2.1 Research Question 1

Research Question 1 can be answered affirmatively because a significant positive relationship existed between composite social presence scores and persistence ratings among students who studied computer science online according to aligned items on the CERP instrument. The rejection of the null hypothesis suggests that students who perceive a higher social presence in their online courses are likelier to persist in their studies. However, the weak correlation coefficient and size of the effect suggest that this conclusion should not be overstated.

The rejection of the null hypothesis also suggests that students who report higher perceptions of social presence also tend to report higher levels of persistence and vice versa. The positive correlation between the two variables may indicate that perceptions of social presence may motivate students to persist in online undergraduate computer science degree programmes. Although the correlation was statistically significant, the strength of the relationship between the two variables was only moderate. Other factors beyond social presence may also affect persistence in online undergraduate computer science degree programmes.

6.2.2 Research Question 2

Research Question 2 can also be answered affirmatively because a significant positive relationship existed between composite social presence scores and student satisfaction ratings among students who studied computer science online according to aligned items on the CERP instrument. The rejection of the null hypothesis indicates that students who perceive a higher level of social presence in their online courses are more satisfied with their learning experience. Like Research Question 1, the weak correlation coefficient and size of the effect suggest that this conclusion should not be overstated.

The rejection of the null hypothesis suggests that people who report higher levels of social presence also tend to report higher levels of satisfaction, and vice versa. The positive correlation between the two variables may indicate that social presence can contribute to overall satisfaction in online undergraduate computer science degree programmes. Although the correlation is statistically significant, the strength of the relationship between the two variables was only moderate. Rejection of the null hypothesis also suggests that other factors beyond social presence may influence satisfaction in online undergraduate computer science degree programmes.

6.2.3 Research Question 3

Like Research Questions 1 and 2, Research Question 3 can be answered affirmatively, but it is perhaps the most interesting finding, especially considering the findings related to the inter-rater reliability of the subconstructs. The subconstructs of social presence, sociability, and social space are all significantly related to each other according to perceptions of students who have studied computer science online according to aligned items on the CERP instrument. The rejection of the null hypothesis suggests that these constructs are interrelated collective indicators of the perception of social presence in online learning environments.

The social presence subconstruct was found to be positively correlated with the sociability subconstruct, with a correlation coefficient of 0.202, which is statistically significant at a 2-tailed significance level of < 0.001. Rejection of the null hypothesis also suggests that students who reported higher perceptions of social presence may also report higher sociability or a higher frequency of interaction in online undergraduate computer science degree programmes. However, the effect was small.

The social presence subconstruct was also found to be positively correlated with the sociability subconstruct, with a correlation coefficient of 0.429, which is statistically significant at a 2-tailed significance level of < 0.001. Rejection of the null hypothesis indicates that students who perceive others as more "real" may also perceive those environments as having greater social space or a sense of belonging in online undergraduate computer science degree programmes. However, again, the effect was small.

Finally, the sociability subconstruct was found to be positively correlated with the sociability subconstruct, with a correlation coefficient of 0.139, which is statistically significant at a 2-tailed significance level of < 0.001. The rejection of the null hypothesis also suggests that more sociable platforms may foster more perceptions of social space in online undergraduate computer science degree programmes. While all three correlations are statistically significant, the strength of the relationships between the variables was only moderate. The rejection of the null hypothesis also indicates that other factors beyond social presence, sociability, and social space may influence students' experiences in online undergraduate computer science degree programmes.

This study contributes to the literature concerning measuring social presence in online learning by providing a comprehensive analysis of the reliability of the social presence construct and its subconstructs. This study applied Cronbach's alpha to each subconstruct and the social

presence composite construct to evaluate internal reliability. The findings indicate that the social presence construct and its subconstructs are internally consistent and highly reliable. Specifically, the social presence subconstruct had a Cronbach's alpha of .853, the social space subconstruct had a Cronbach's alpha of .700, and the sociability subconstruct had a Cronbach's alpha of .540. In addition, the composite social presence construct had a Cronbach's alpha of .817. These reliability findings support the validity of the measures used to assess social presence according to aligned items on the CERP instrument. This study's reliability analysis provides important insights into measuring social presence in online learning and can contribute to the ongoing development of the theory and practice of online learning.

This study highlights the importance of using reliable measures to assess social presence in online learning environments. As noted by Tu and McIsaac (2002), "reliable measures are critical for developing an accurate picture of the construct being assessed and can increase the validity of the results obtained" (p. 192). Therefore, the findings of this study can inform future research on social presence in online learning by providing a reliable measure that can be used to assess the construct using different permutations of analysis on the CERP dataset.

6.3 Interpretations Related to the Literature

The findings of this study provide insights into how social presence relates to attrition rates in online computer science courses and programmes. Previous research has found that perceived social presence can affect students' persistence in online courses (Miao & Ma, 2022; Gunawardena & Zittle, 1997; Richardson & Swan, 2003). The results of this study support these findings, as the composite social presence scores were significantly and positively correlated with persistence ratings among the students in the sample.

Moreover, this study's findings have revealed that composite social presence scores were significantly and positively correlated with student satisfaction ratings. This result is consistent with previous research that has found a positive relationship between social presence and student satisfaction in online courses (Tu & McIsaac, 2002; Lowenthal & Dunlap, 2019). Thus, the results of this study suggest that increasing social presence in online computer science courses may improve student persistence and satisfaction.

Karel Kreijns and colleagues have researched social presence theory extensively in online learning environments. They have examined various aspects of social presence theory, including the relationship between social presence and students' satisfaction and persistence in

online courses, the impact of different instructional strategies on social presence, and the use of technology to enhance social presence in online learning. Previous studies affirm that social presence significantly positively affects students' satisfaction and persistence in online courses (Kreijns et al., 2021; Kreijns et al., 2013; Kreijns, Kirschner & Jochems, 2003).

Kreijns and his colleagues' research suggests that social presence is a viable theory for understanding and improving online learning experiences. By designing instructional strategies and using technology to enhance social presence, instructors can help to improve students' satisfaction and persistence in online courses. In this sense, social presence theory can loosely relate to instructional design theories such as transactional distance, constructivism, constructionism, and connectivism in the context of computer science education (Ben-Ari, 1998).

This study's findings are also consistent with the Community of Inquiry (CoI) framework, which posits that social presence, cognitive presence, and teaching presence are all necessary components of a successful online learning experience. In particular, the reliability analysis of this study provides important insights into the measurement of social presence in online learning and can contribute to the ongoing development of the theory and practice of online learning. CoI frameworks tend to define social presence a bit differently from the Kreijns et al. (2021) definition. However, the subconstructs and alignment with the CERP survey instrument may support existing studies surrounding measures of social presence in CoI contexts.

The social presence subconstruct for this study was based on alignment with questions from the CERP survey, three of which assessed experiences of support from mentors and two related to student identity in computing. The questions were not originally intended to measure social presence per se. However, for online students, experiencing authenticity from instructors and mentors and developing and disclosing a sense of identity as a "computer science person" are justifiable factors relating to the notion of "realness" or "salience" in computer-mediated telecommunications (CMC) exchanges (Short et al., 1976), especially in online computer science degree programmes. Neureiter, Vollmer, Gerwert Vaz de Carvalho & Tscheligi (2017) affirmed that "e-mentoring" initiatives have been successful in computer science education. Considering a general consensus from the prevailing literature, issues surrounding instructor immediacy, self-disclosure, and social identity are all relevant to how the social presence subconstruct was conceptualised for this study.

The CERP survey questions concerning support dealt with experiences related to sharing perspectives, encouragement, and feedback. Instructor feedback, online discussion forums, and collaborative learning activities can enhance social presence in online courses (Kreijns et al., 2014). Instructor immediacy relates to social presence theory because it reduces the perceived transactional distance between learners and the learning process (Arbaugh, 2001). Acknowledging that a Community of Inquiry (CoI) is difficult to establish in an online learning environment, Lowenthal and Dunlap (2010) promote the notion of "digital storytelling" in primarily text-based courses. Storytelling can establish and enhance the social presence of instructors.

Identity formation in online learning environments relates to a sense of belonging and the sociability subconstruct. The sociability subconstruct was based on questions about feeling welcomed by and supported in a computer science department. Perhaps most important for issues surrounding attrition related to traditionally marginalised groups from computer science, such as racial minorities and women, social space relates closely to the overall notion of a Community of Inquiry and a "sense of community" in online learning courses and programmes (Rovai, 2018; McMillan & Chavis, 1986).

Patrick Lowenthal and Vanessa Dennen (2017) ask important questions about "issues of social presence and identity, both of which are complex, multi-faceted, closely interrelated constructs" in the online learning environment (p. 137). Lowenthal and Dennen explored the interrelationship between identity, community, and the roles of social networking platforms and synchronous communication technologies in improving perceptions of social presence. Establishing social presence and identity online can be challenging due to the limitations of communication mediums and perceptions of transactional distance. Lowenthal and Dennen acknowledge that, like Goffman's dramaturgy sociological theory, learners and instructors might "tell" one another who they are in the online environment, but neither is entirely in control of how each perceives the other. Notably, identities shared in online learning environments include "not only the identity one shares while being present in a class, but also the identity that is refined and developed within the class – an identity that may be focused on entering a profession" (p. 138). Such identity formation may be particularly important for underrepresented and marginalised students who need opportunities to feel as if they are, in fact, "a computing person" and part of a "computing community," which can foster self-efficacy (Bandura, 1993; Bandura, 1977). In fact, "computing identity mentoring" has been

implemented at several institutions to enhance "students' self-efficacy regarding computing" (Boyer, Thomas, Rorrer, Cooper & Vouk, 2010, p. 167).

In this study, the sociability subconstruct was based on questions from the CERP survey about the frequency of interaction with instructors and peers. The frequency of peer interaction in online STEM courses, especially among underrepresented students, can predict persistence. In fact, monitoring students' interactions, such as discussion forum participation, in the first two weeks of a course can support student success (Bosch et al., 2018). Similarly, Moon-Heum Cho and Scott Tobias (2016) found that social presence was a significant factor in establishing a Community of Inquiry in online courses. Incidentally, teaching presence and cognitive presence were not significant factors. Instructor participation in the discussions, when compared with discussions with no instructor participation, was a key factor related to student satisfaction and achievement. Frequency of interactions may not be the best way to measure sociability, but such measures do speak to the capacity of the tool or platform to allow for social interaction – what Kehrwald (2008) once called "social affordances" (p. 98).

Moreover, a tangential consideration is that social media may be a confounding factor in this study and other relevant studies. The technological sociability of Learning Management Systems (LMSs) may be limited compared to prevailing social media platforms. Because the findings of this study were only weak correlations between satisfaction and social presence, the extent to which social presence alone can redress the problem of attrition in online computer science degree programmes is minimal. Lowenthal's insight (2011) that social media external to formal learning platforms may influence social presence in formal courses warrants consideration. Turkle (2016) worries that social media and online communication tools may erode students' ability to connect with others meaningfully. Social media interactions often lack the richness and depth of face-to-face communication, which could have a negative impact on students' abilities to develop meaningful social presence in online learning environments (Turkle, 2012). Concerning attrition from computer science degree programmes, Turkle's intuition that the social isolation caused by excessive reliance on digital communication may contribute to the problem. Computer science students often feel overwhelmed and unsupported. Online communication alone may not sufficiently provide the social support and mentorship necessary for students to succeed in such programmes (Turkle, 2015). Turkle's concerns suggest that social media platforms have benefits but may also have unintended consequences that could impact social presence and retention in computer science degree programmes. One

such benefit might be “e-mentoring” for computer science students using social media platforms like Facebook (Lee et al., 2011).

Finally, this study evaluated the social presence, sociability, and sociability subconstructs and found that all three were positively and statistically significantly correlated. This finding is consistent with previous research on social presence as a multidimensional construct (Kreijns et al., 2021; Biocca et al., 2003; Tu & McIsaac, 2002). The subconstructs can be used to advance research on the conceptualisation and measurement of social presence in online learning broadly and computer science degree programmes specifically.

6.4 Implications

This study’s findings on perceptions of social presence and the persistence and satisfaction of students can provide insights into addressing the problem of attrition in online undergraduate computer science degree programmes. Moreover, correlational research can support theory development by providing converging evidence with experiments with high internal validity (Price et al., 2013). Finally, implications for best practices concerning online learning in general and online computer science degree programmes specifically are presented.

6.4.1 Implications for Online Learning in General

Firstly, the findings suggest that creating a social and interactive learning environment can improve students’ sense of social presence, positively associated with student satisfaction and persistence in online courses (Gunawardena et al., 2009; Richardson & Swan, 2003). Therefore, instructors should implement online discussions, group projects, and other opportunities to foster peer-peer and instructor-student interactions. Moreover, by enhancing perceptions of social presence through discussion forums, collaborative activities, and other interactive tools, online instructors can support the development of constructionist and constructivist learning environments that encourage students to construct knowledge together. However, due to the small effect sizes of the findings, the relationship between social presence and student satisfaction and persistence should not be overestimated.

Secondly, this study implies that timely feedback and support can enhance students’ perceptions of social presence and encourage their persistence in online courses (Richardson & Swan, 2003). For example, instructors should offer personalised feedback on assignments, prompt responses to students’ questions, and opportunities for one-on-one consultations. Because one of the CERP survey questions comprising the social presence subconstruct relates

specifically to instructor feedback, an implication suggests that substantive and timely feedback can enhance perceptions of social presence in online learning courses and programmes.

Finally, the results suggest that instructors should ensure that instructional design enhances the frequency of social interaction, as this can affect students' perception of social presence and their overall satisfaction (Richardson & Swan, 2003). Sociability, the extent to which the technologies themselves enable or encourage frequent interaction, is an important subconstruct examined in this study. Instructors must collaborate with instructional designers to ensure that the online course is user-friendly and that the layout and interface facilitate interaction and engagement. Best practices in online course delivery can enhance other modalities, such as blended learning (Arbaugh, 2014).

This study's findings suggest that creating a social and interactive learning environment, providing timely feedback and support, and paying attention to the design and usability of the online learning platform can enhance students' sense of social presence, satisfaction, and persistence in online courses, which may ultimately address the problem of attrition in computer science degree programmes. Furthermore, instructors can implement effective strategies to increase social presence in online courses by understanding the different subconstructs of social presence and how they relate to student outcomes. The results of this study suggest that increasing social presence in online computer science courses may be a promising approach to reducing attrition rates and increasing student satisfaction, albeit with minimal effect.

6.4.2 Implications for Online Computer Science Degree Programmes

Student persistence and satisfaction in online computer science degree programmes are related to attrition and retention. Social presence is critical to fostering effective collaboration and communication in online computer science courses. As computer science students prepare to work with collaborative programming repositories and team-oriented tools, creating a sense of community through social space and a supportive environment can motivate marginalised students to persist in computer science degree programmes. In addition, social presence can help combat feelings of disengagement and isolation, which can decrease motivation and lead to attrition.

This study found a significant positive correlation between composite social presence and persistence in online computer science degree programmes. A relationship between social presence and persistence suggests that students who feel more socially present in their online learning environment are more likely to persist in their studies. This finding is important for instructional designers as they should create environments that foster social presence, sociability, and social space to improve student persistence rates. However, as Oh et al. (2018) rightly observed, simply attempting to increase perceptions of social presence in online courses may not have "uniformly positive results" (Oh et al., 2018, p. 25). Social presence is not a panacea for addressing the problem of attrition in online computer science degree programmes.

Nevertheless, social presence can enhance collaboration and communication to encourage student persistence, if not dramatically improve it. Students who communicate and work together are better equipped to solve problems and complete projects. Therefore, computer science students must be prepared to work with collaborative programming repositories like GitHub and team-oriented tools like Slack or Google Workspaces (Chen et al., 2018). In the computer science industry, for example, collaborative programming teams have been found to outperform individual programmers (Nosek, 1998). In fact, cohort-based learning communities coupled with academic support have shown promising results in fostering "a clear pathway for upward socio-economic mobility into the high-paying technology industry" for underrepresented upper-division students in computer science degree programmes (Narayanan et al., 2018, p. 705).

Additionally, social presence may ameliorate feelings of disengagement and isolation, negatively impacting motivation and leading to attrition. Creating a sense of community through social space and a supportive environment can motivate marginalised students to persist in computer science degree programmes (Chiu, Lin & Lonka, 2021; Holder, 2005). During the first two critical years of undergraduate computer science degree programmes, mentors can fulfil "technical and social roles assisting freshmen with the transition to university and with their studies in computer science" (Miller & Kay, 2002, p. 9). Providing mentorship and role models who share similar experiences can help students feel less alone and more connected to the field (Hehir, Zeller, Luckhurst & Chandler, 2021). Role models can be especially important for women and racial minorities who may not have many role models in the computer science field (Sealy & Singh, 2006).

Another important finding from this study is a statistically significant positive correlation between composite social presence and student satisfaction in online computer science degree programmes. A relationship between social presence and satisfaction suggests that students who feel more socially present in their online learning environment are more likely to be satisfied with their studies. Therefore, instructional designers must create online courses that foster social presence to improve student satisfaction rates. Sociable and well-designed online courses are important as satisfied students are more likely to be engaged in their studies and perform better academically.

Lack of diversity in computer science can be mitigated by enhancing feelings of belonging in a social space (Leigh et al., 2022). Both social presence theory and connectivism acknowledge that learning is a social and collaborative process enriched by interactions and relationships between students and instructors. Courses with intentional social space can promote a sense of belonging and provide access to shared resources and support to improve student satisfaction. Access to resources, such as mentorship and networking opportunities, can be especially valuable for marginalised students who may face additional challenges in navigating the computer science field (Doak, 2022).

Online learning environments are uniquely positioned to provide students with equitable access to resources and support (Bylieva, Hong, Lobatyuk & Nam, 2021). Accessing and sharing resources and participating in mentoring activities can enhance students' self-efficacy. By encouraging students to pursue opportunities and secure needed resources to persist in their studies, self-efficacy can be developed, especially for students from marginalised backgrounds. Fostering students' self-efficacy through knowledge and resource sharing supports the connectivism theory's emphasis on the role of networks and connections between people, resources, and ideas. Apart from fully online learning, blended learning may also expand opportunities and enhance the efficacy of students who have been traditionally underrepresented (Mayr & Oppl, 2022).

The focus of this study was not on parsing persistence and satisfaction data on demographic factors. However, it is worth considering how students were represented in the dataset. The largest percentage of students in the CERP dataset indicated that they enrolled in an online degree programme because the programme they were interested in was only available online (34%). Among students who studied computer science online, 48% were White, and 40% were Asian. Together, these two racial categories accounted for 88% of students. Black, Arab,

Indigenous, Native, and Others accounted for just 12% of the students. According to the CERP dataset, only 24% of the students who studied computer science online were women, and just 1.4% identified as non-binary. Incidentally, the percentage of women in the dataset is consistent with but slightly higher than national statistics on women who study computer science in the United States as of 2019, which was about 22% (NCWIT, 2021). Only 3% of students identified as homosexual, and 7% as bisexual. About 3% identified as asexual or "something else." No students in the dataset self-identified as transgender. Consistent with the literature, these data suggest that computer science is still an academic field dominated by white males, which may make it more challenging for traditionally underrepresented and marginalised students to persist and graduate.

Creating a sense of belonging in online computer science degree programmes may mitigate such marginalisation. To nurture social space in online computer science courses, opportunities for interaction with classmates and instructors through discussion forums and collaborative tools are essential (McInnerney & Roberts, 2006). The use of audio and video technologies can also enhance social presence (Kreijns et al., 2014). Creating a sense of community and support through social presence can lead to better retention rates, improved academic performance, and a more satisfying learning experience for computer science students (Lowenthal & Dunlap, 2010).

Creating a social space in online computer science courses is essential to improve student retention, academic achievement, and satisfaction. Instructors can foster a sense of community and mutual support in online learning environments by providing opportunities for interaction with classmates and instructors, mentorship, and networking (Gourlay et al., 2021). Social space is especially important for marginalised students who may face additional challenges when navigating the computer science field. Enhancing perceptions of social presence in online computer science degree programmes can help create a more equitable and satisfying learning experience for all students and may mitigate the attrition problem. However, due to the small effect sizes of this study's findings, efforts to enhance perceptions of social presence might only have a minimal effect on student persistence and satisfaction in online computer science degree programmes.

6.5 Summary

The implications of this study suggest that providing timely feedback and support and paying attention to the design and usability of the online learning platform can enhance students' sense

of social presence and improve satisfaction and persistence in online courses. These findings have broader implications for online learning in general, as they suggest that instructors should implement online discussions, group projects, and other opportunities to foster peer-peer and instructor-student interactions. Instructors should also offer personalised feedback on assignments, prompt responses to students' questions, and opportunities for one-on-one consultations.

In the context of online computer science degree programmes, creating a sense of community and ensuring a supportive environment through social space can motivate marginalised students to persist in computer science degree programmes. Students who perceive greater social presence in their online learning environment may be more likely to persist and be satisfied with their studies. Furthermore, creating an intentional social space can promote a sense of belonging and provide access to shared resources to improve student satisfaction. Access to resources, such as mentorship and networking opportunities, can be especially valuable for marginalised students who may face additional challenges in navigating the computer science field. However, it is worth considering student representation in the dataset.The field of computer science continues to be predominantly composed of white males, potentially inhibiting students from traditionally underrepresented and marginalised backgrounds from persevering and completing their degree programmes.

Chapter 7 Conclusion and Recommendations

7.1 Introduction

In explanatory correlational studies, the focus is on testing hypotheses based on a theory. Therefore, a priori expectations about the direction and strength of the relationship between the variables are common, and the research aim is to provide evidence supporting a theory. Although not causal, one variable is typically conceived as the independent variable, which is thought to cause changes in the dependent variable (Creswell & Creswell, 2018; Rea & Parker, 2014). In this study, the social presence composite construct can be conceived as an independent variable, and student persistence and satisfaction can be conceived as dependent variables. Although no attempts were made to ascribe a causal relationship between these variables, it is reasonable to suggest that the findings of this study can be interpreted in terms of the extent to which perceptions of social presence are related to higher student persistence and higher student satisfaction in online computer science undergraduate degree programmes.

7.2 Limitations

Several factors limited this study. The scope and generalisability, a correlational design, non-normality of data, nonparametric tests, and the narrow scope of measures all limited the findings and implications of this study.

Firstly, the sample was limited to undergraduate students who studied computer science online and completed the CERP survey instrument. Therefore, the findings may not be generalisable to other populations or contexts beyond the institutions that participated in the Data Buddies project. The findings only apply to students who completed the CERP survey and met the inclusion criteria (n = 1,646). Moreover, this study relied on self-reported responses to the CERP survey, which may be subject to bias and may not accurately reflect the behaviours or attitudes of students.

Secondly, this study used a correlational design which, although helpful in examining relationships between variables, should not be considered a causal inference. Therefore, it is impossible to determine whether social presence improves student satisfaction or persistence. Other factors may account for the observed relationships. The design was not experimental or even quasi-experimental and this study did not control for other variables that may have

influenced relationships between the variables. A lack of control, and the correlational nature of this study, limit its internal validity.

Thirdly, data were not normally distributed, as indicated by the results of the normality tests. Nonnormality also limits the generalisability of the findings and may have affected the validity of the statistical analyses. The decision to use nonparametric tests may be the reason for weak effect sizes. Although statistical power was strong due to the relatively large sample size, it must be considered in tandem with weak effect sizes.

Fourthly, because this study was bounded to the dataset, only students studying computer science at institutions in the United States were included in the sample. Western biases may be prevalent, limiting transferability and generalisability beyond this study's narrow scope. Broader, more global perspectives considering non-Western approaches to computer science education and online learning were excluded from the findings.

Finally, this study used only one instrument to measure social presence, student satisfaction, and persistence. Its narrow scope limits the validity of the results, as other measures may have yielded different results. Although the subconstructs were found to be moderate to strongly internally consistent, issues related to construct and criterion validity limited this study's internal and external validity.

7.3 Recommendations

Because this study found a significant positive correlation between composite social presence and student persistence and satisfaction, it is recommended that online course designers consider incorporating features that enhance social presence in their courses. Although social presence itself is not a causal factor in student persistence or satisfaction and cannot unilaterally reduce attrition, a relationship between these factors suggests that it is worth the effort to intentionally foster social presence for the benefit of students in online computer science degree programmes. In addition, loneliness and social isolation may contribute to the problem of attrition, which might be ameliorated by improving students' perceptions of social presence. Three major recommendations are provided: feedback as social presence, a sense of community as social space, and instructional design as sociability. Recommendations for future research are also included.

7.3.1 Acknowledge Loneliness and Social Isolation

Due to the highly technical nature of computer science programmes, the curriculum can tend to focus on independent skill development over collaborative interactions (McDowell, Werner, Bullock & Fernald, 2002). For computer science students, the transition to college or university alone can have adverse psychological effects leading to feelings of loneliness and social isolation (Bordini & Korn, 2020). While learning the mathematical, algorithmic, and applied skills related to computer science is important, students studying online can feel a sense of loneliness and social isolation during their studies (LaRoche, 2009). For example, effective introductory programming courses are a "problem-solving journey" involving "conceptual unclarities, design dilemmas, [and] algorithmic challenges" that are often overcome through feedback, interaction, and collaboration (Charitsis, Piech & Mitchell, 2022, p. 1150). Furthermore, particularly the process of explaining code students have written to their peers and instructors, can strengthen comprehension (Lehtinen, Lukkarinen & Haaranen, 2021; Gray, Edwards, Lewandowski & Shende, 2005). While sociable computer-mediated communication technologies can help students overcome feelings of social isolation and loneliness, they should not displace university support services and mental health interventions (Harrison et al., 2022).

Based on the findings of this study, specific recommendations related to feedback, a sense of community, and instructional design may help mitigate loneliness and social isolation for students in online computer science degree programmes. Additionally, such recommendations may help address the attrition problem by motivating students to persist and by improving satisfaction with their learning experiences.

7.3.2 Provide Feedback as Social Presence

Firstly, this study found a positive correlation between student persistence and social presence, suggesting that providing online students feedback and support can enhance their persistence. Therefore, instructors should consider providing regular feedback and offering support services to help students overcome challenges while studying online. Instructors and institutions should proactively provide support and substantive feedback to enhance student persistence, such as offering support services to help students overcome challenges they may encounter while studying online. Timely feedback on assignments can also increase their likelihood of persisting in online computer science degree programmes. Feedback is especially important in programming, higher-level mathematics, logic, and algorithmic courses, where academic rigour intensifies and attrition is more likely (White & Massiha, 2016). Feedback may also manifest instructor presence (Oyarzun et al., 2018).

Inviting student feedback can also enhance social presence in online courses (Li, 2022). Evaluating and improving the social presence of online computer science courses through gathering feedback from students and incorporating their suggestions in future course revisions can also help create a more engaging and supportive online learning environment, which may reduce attrition in online computer science degree programmes. If social presence is a critical factor in online learning, it is recommended that online course designers and instructors regularly evaluate and improve the social presence of their courses. Social presence evaluation can be done by using instruments such as the CERP survey to monitor students' experiences. Regular opportunities for students to give feedback on the course and their online learning experience should be incorporated into the course structure (Richardson & Swan, 2019).

7.3.3 Instil a Sense of Community as Social Space

Secondly, attrition from computer science programmes has been highest among "women and underrepresented minorities" (Cohon & Hambrusch, 2018, p. 5). Students may also experience identity formation in the computing community by nurturing a sense of belonging in the social space. Incorporating group activities that encourage communication and collaboration, providing clear guidelines and expectations for participation and communication, and fostering a supportive and respectful online environment that values diversity and inclusion can also help create a sense of community among online computer science students, which may increase students' motivation to persist in online computer science degree programmes. Clear guidelines and expectations for participation and communication in the online environment should be provided (Miao & Ma, 2022; Gunawardena & Zittle, 1997). Students do not necessarily express less satisfaction with online computer science courses based solely on their level of difficulty, but levels of interactivity and peer support have been found to affect student satisfaction positively (Farag et al., 2019).

Social presence is a key component of community building in online courses, and instructors should design activities and assignments that foster social interaction and collaboration among students (Fiock, 2020). The Community of Inquiry (CoI) framework recognises a relationship between teaching presence, social presence, and student sense of community in online courses. Social presence is positively related to students' sense of community, and teaching presence is critical in fostering social interaction and collaboration among students (Shea, Sau Li & Pickett, 2006). Instructors should foster a supportive and respectful online learning environment that values diversity and inclusivity (Lakhal & Mukamurera, 2021; Gunawardena & Zittle, 1997).

7.3.4 Improve Instructional Design as Sociability

Thirdly, this study found a positive correlation between sociability and social presence, which indicates that the extent to which the CMC technology or LMS is sociable relates to the extent to which social presence is perceived. Therefore, online course designers and instructors should enhance the sociability of LMSs by enhancing the sociability of the technological platforms themselves. Because computer science is a collaborative profession, it may help incorporate group activities beyond conventional discussion boards that encourage student communication and collaboration (Stoytcheva, 2021). Assessment methods to evaluate student learning, including group projects and collaborative assignments, should be carefully designed with social presence theory in mind (Richardson & Swan, 2019).

Designing online courses with features that enhance social presence, such as incorporating activities that allow for interactions between students and instructors and opportunities for students to interact with each other, can help online computer science students feel more socially present to their instructors and peers, which may increase their likelihood of persisting in the programme. Minimally, instructors should actively participate in online discussions to demonstrate teacher presence (Richardson & Swan, 2019). In addition, instructors should consider encouraging social presence indicators, such as emoticons, appropriate humour, and professional self-disclosure, thereby increasing students' perceptions of social presence (Miao & Ma, 2022; Lakhal & Mukamurera, 2021; Tung & Deng, 2007; Derks, Bos & Grumbkow, 2004; Gunawardena & Zittle, 1997). There is a surprising abundance of research on using emoticons in computer-mediated communication related to social presence, psychology, and even neuroscience (Aldunate & González-Ibáñez, 2017).

Although this study has focused on measures of social presence in text-based environments, the CERP survey did not specify what constitutes "entirely online" learning. While it can be assumed that most LMSs use a primarily text-based approach for interaction between instructors and students, research suggests that rich media and synchronous communication tools enhance perceptions of social presence. In fact, future online learning environments may include immersive technologies and virtual reality (Oh et al., 2018). Patrick Lowenthal and Joanna Dunlap (2019) suggest that live synchronous web meetings can increase social presence in online courses, increasing student engagement and retention. Instructors should utilise computer-mediated communication tools available for real-time interaction, such as text messages, social media, chats, or video conferencing (Richardson & Swan, 2019).

Synchronous interaction with instructors may be particularly useful in the first two years of computer science degree programmes, where attrition rates have been the highest (White & Massiha, 2016).

7.3.5 Recommendations for Future Research

The findings of this study are preliminary and should provoke future research. Because the CERP dataset will continue to grow, replicating aspects of this study with new data may enhance its reliability. Recommendations include expanding this study, utilising different research designs, investigating different factors, expanding the population, and enhancing the validity of the constructs.

Firstly, future studies should expand on this study's research methodology and design. Future studies should examine the causal relationship between social presence, student persistence, and student satisfaction in online undergraduate computer science degree programmes. Approaches could include experimental or quasi-experimental research designs that allow for manipulating social presence to observe the effect on student outcomes. This study has only provided a snapshot of the relationship between social presence and student persistence and satisfaction based on the CERP dataset. Future studies can be conducted longitudinally to examine whether social presence changes are associated with student persistence and satisfaction. Future studies can also use other measures to examine social presence and its relationship with student persistence and satisfaction. Mixed-methods research could provide a more holistic understanding of the perceptions of social presence for students studying computer science online.

Secondly, future studies should expand data beyond the CERP dataset, which is comprised only of students studying computer science at institutions in the United States. Non-Western perspectives on computer science education, particularly regarding social space and collaboration, may yield more interesting findings about the relationship between social presence and student attrition and satisfaction.

Thirdly, future research could examine the role of other variables beyond social presence in predicting student persistence and satisfaction in online undergraduate computer science degree programmes. For instance, personality traits, self-efficacy, and academic background could be examined concerning persistence and satisfaction. Although this study found a statistically significant positive relationship between social presence and student persistence

and satisfaction, future studies could examine other variables affecting the experiences of online computer science students, such as motivation, self-efficacy, and learning styles.

Fourthly, future studies could examine the relationship between social presence and other important student outcomes, such as academic achievement and engagement. Examining other relevant outcomes would enhance understanding of perceptions of social presence in online learning environments. Moreover, future research can examine cultural differences in the perception of social presence and its impact on student persistence and satisfaction in online computer science undergraduate degree programmes. Understanding cultural differences can provide insights into how online learning experiences can be tailored to meet the needs of students from diverse cultural, racial, and ethnic backgrounds. Similar analyses could be performed based on other perennial factors related to attrition in computer science education, such as gender.

Fifthly, improvements should be made to the construct and criterion validity of the social presence measures. Although the subconstructs devised for this study were internally reliable, ensuring stronger validity could enhance future studies, even using the same CERP dataset. Moreover, the measures of persistence and satisfaction should be enhanced to include more than one item to improve the validity of those measures.

Sixthly, future research could examine perceptions of social presence in other online learning contexts beyond undergraduate computer science, including graduate-level degree programmes and informal learning such as online coding boot camps and professional certifications. Because higher education is changing, non-traditional online computer science education may be an important aspect of STEM workforce development.

Finally, future studies could examine how social presence can be effectively fostered through the intentional design of online courses and the features of LMSs. For example, future research can examine the relationships between instructor presence and student persistence and satisfaction in online computer science undergraduate degree programmes. Introducing instructor presence as a separate subconstruct could provide insights into the role of instructors in creating a supportive and engaging online learning environment. Understanding the role of instructor presence related to social presence could guide instructors and instructional designers in creating online learning experiences that foster social presence, ultimately improving student persistence and satisfaction.

7.4 Conclusion

In conclusion, this study examined the relationship between social presence, student satisfaction, and persistence in online computer science undergraduate degree programmes. As an ex post facto correlational study using archival data from the CERP Data Buddies dataset, this study applied Spearman's rank procedure to test non-normal data that did not meet assumptions tests. All three null hypotheses were rejected. Post hoc procedures revealed weak effect sizes but strong power due to the large sample size. The three subconstructs used in this study – social presence, sociability, and social space – were found to have strong internal consistency and reliability.

Findings suggest a significant positive relationship between composite social presence scores and persistence and satisfaction ratings among online computer science students. Furthermore, the null hypotheses of this study were rejected, suggesting that students who perceive a higher social presence in online courses tend to persist in their studies and are more satisfied. However, the weak to moderate correlation coefficients and small effect sizes suggest that other factors may also influence students' experiences in online undergraduate computer science degree programmes. Therefore, social presence should not be overestimated as a unilateral factor related to student persistence and satisfaction.

This study's findings are consistent with previous research on social presence and related theories such as the Community of Inquiry framework, which suggests that social presence, cognitive presence, and teaching presence are necessary components of a successful online learning experience. This study also provides important insights into measuring social presence in online learning and can contribute to the ongoing development of the theory and practice of online learning. Strong reliability findings between the subconstructs of social presence, sociability, and social space contribute to ongoing research on conceptualising and measuring social presence constructs. The three research questions were answered, and the three research objectives were attained.

However, this study has limitations, including a correlational design, non-normality of data, nonparametric tests, small effect sizes, and a narrow scope of measures. Further, because this study was bounded to the archival dataset, only students studying computer science at institutions in the United States were included in the population. Because technology is a fundamental aspect of culture, and the global nature of the problem is well-documented in the literature, future studies should consider other non-Western contexts (Gumbo, 2017).

Institutions can improve students' satisfaction and persistence in online computer science programmes by applying instructional design strategies that enhance social presence. Fostering belonging through social space, providing timely feedback and support, and attending to the design and usability of the online learning platform can enhance students' perceptions of social presence. Moreover, increasing social presence in online computer science courses may be a promising approach to reducing attrition rates and increasing student satisfaction, especially among underrepresented and marginalised student groups (Albarakati, 2020). This study addressed a problem in computer science education that might inspire constructive changes in instructional practices by technology educators, especially those teaching computer science online.

In conclusion, this study provides insights into how social presence relates to student satisfaction and persistence in online computer science undergraduate degree programmes. The findings suggest that social presence contributes to a successful online learning environment and should be considered part of instructional strategies for online computer science degree programmes.

Reflection

This study was personally important to me for several reasons. Firstly, I have spent the past two decades of my career engaged in online learning as a student, instructor, course developer, and higher education administrator. Secondly, I started my undergraduate career as a computer science student and changed my major before completing my degree programme. Later, as a mature adult learner and after earning a PhD in a different field, I completed online graduate certificates in computer science education, data science, and machine learning. Thirdly, I have taught several online undergraduate computer science courses for a large institution. As an instructor, I have strived to increase social presence to improve completion and retention rates. I am passionate about "humanising" online computer science courses to serve students more effectively. Finally, I have also spent most of my career serving marginalised student populations. I care deeply about doing what I can to improve retention in STEM fields for students traditionally excluded or lacking the resources and support to persist to graduation.

The process of conducting the study was personally enriching because I enjoy quantitative research. Using a large dataset from a national source made the study more interesting because I did not have to settle for a small sample size or struggle to recruit participants to reach an arbitrary threshold. The data were already collected, anonymised, and ready for analysis. Testing the hypotheses and evaluating the results is always exciting because the results become even more interesting after the rigorous process of developing a research proposal and conducting a literature review. Measuring the validity of the subconstructs was perhaps most interesting, as I think it has the most potential to contribute to the extensive literature surrounding social presence theory. Professor Mishack Gumbo provided insight, constructive critique, and helpful feedback each step of the way throughout the research process.

I intend to use the results of this study to contribute to scholarly conversations surrounding attrition in computer science education and hope the CRA will publish the results to its constituency, considering that I utilised its dataset. I also hope to devise specific interventions, and perhaps even algorithms, to enhance what I see as stagnating practices in online learning such as rote discussion forums and listless instructor announcements in courses. Finally, while certainly not a panacea to the attrition problem, I hope to help computer science instructors understand the importance of social presence theory in online learning, so that students can have better, more meaningful experiences in their degree programmes.

References

Ackerman, E. (2001). *Piaget's constructivism, Papert's constructionism: What's the difference?* Future of learning group publication, 5 (3). http://www.sylviastipich.com/wp-content/uploads/2015/04/Coursera-Piaget-_-Papert.pdf

Aichner, T., Grünfelder, M., Maurer, O., & Jegeni, D. (2021). Twenty-five years of social media: A review of social media applications and definitions from 1994 to 2019. *Cyberpsychology, Behavior, and Social Networking*, *24*(4), 215–222. https://doi.org/10.1089/cyber.2020.0134

Ajoodha, R., Jadhav, A., & Dukhan, S. (2020). Forecasting learner attrition for student success at a South African university. *SAICSIT 20: Conference of the South African Institute of Computer Scientists and Information Technologists*, *September*, 19–28. https://doi.org/10.1145/3410886.3410973

Akcaoglu, M., & Lee, E. (2016). Increasing social presence in online learning through small group discussions. *The International Review of Research in Open and Distributed Learning*, *17*(3). https://doi.org/10.19173/irrodl.v17i3.2293

Akyol, Z. (2013). Metacognitive development within the community of inquiry. In Z. Akyol & D. Garrison (Eds.), *Educational communities of inquiry* (pp. 30–44). IGI Global. https://doi.org/10.4018/978-1-4666-2110-7.ch003

Albarakati, N. (2020). The attrition of underrepresented students in computer science. *SIGCSE '20: Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, *20*, 1427. https://doi.org/10.1145/3328778.3372696

Aldunate, N., & González-Ibáñez, R. (2017). An integrated review of emoticons in computer-mediated communication. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.02061

Alqurashi, E. (2018). Predicting student satisfaction and perceived learning within online learning environments. *Distance Education*, *40*(1), 133–148. https://doi.org/10.1080/01587919.2018.1553562

Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. (2001). Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks*, *5*(2), 1–17. https://doi.org/10.24059/olj.v5i2.1875

Annand, D. (2011). *Social presence within the community of inquiry framework* (EJ963922). ERIC. https://eric.ed.gov/?id=EJ963922

Arbaugh, J. (2001). How instructor immediacy behaviors affect student satisfaction and learning in web-based courses. *Business Communication Quarterly*, *64*(4), 42–54. https://doi.org/10.1177/108056990106400405

Arbaugh, J. B. (2014). What might online delivery teach us about blended management education? Prior perspectives and future directions. *Journal of Management Education*, *38*(6), 784–817. https://doi.org/10.1177/1052562914534244

Argyle, M., & Dean, J. (1965). Eye contact, distance and affiliation. *Sociometry*, *28*(3), 289–304.

Aymerich-Franch, L., Karutz, C., & Bailenson, J. (2012). *Effects of facial and voice similarity on presence in a public speaking virtual environment* (Conference: Proceedings of the International Society for Presence Research Annual Conference).

Bandura, A. (1969). Social-learning theory of identificatory processes. In D. A. Goselin (Ed.), *Handbook of socialization theory and research* (pp. 213–262). Rand McNally & Company.

Bandura, A. (1976). *Social learning theory* (1st ed.). Prentice-Hall.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295x.84.2.191

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117–148. https://doi.org/10.1207/s15326985ep2802_3

Bandura, A. (1997). *Self-efficacy: The exercise of control* (1st ed.). Worth Publishers.

Barak, M. (2020). Problem-, project- and design-based learning: Their relationship to teaching science, technology and engineering in school. *Journal of Problem-Based Learning*, *7*(2), 94–97. https://doi.org/10.24313/jpbl.2020.00227

Bawa, P. (2016). Retention in online courses. *SAGE Open*, *6*(1), 215824401562177. https://doi.org/10.1177/2158244015621777

Beaubouef, T., & Mason, J. (2005). Why the high attrition rate for computer science students. *ACM SIGCSE Bulletin*, *37*(2), 103–106. https://doi.org/10.1145/1083431.1083474

Ben-Ari, M. (1998). Constructivism in computer science education. *ACM SIGCSE Bulletin*, *30*(1), 257–261. https://doi.org/10.1145/274790.274308

Bengesai, A. V., & Pocock, J. (2021). Patterns of persistence among engineering students at a South African university: A decision tree analysis. *South African Journal of Science*, *117*(3/4), 1–9. https://doi.org/10.17159/sajs.2021/7712

Bente, G. (2008). Avatar-mediated networking: increasing social presence and interpersonal trust in net-based collaborations. *Human Communication Research*, *2*(1), 287–318. https://doi.org/10.1111/j.1468-2958.2008.00322.x

Bhandari, P. (2022, July 21). *Internal vs. external validity*. Scribbr. https://www.scribbr.com/methodology/internal-vs-external-validity/

Biocca, F. (1997). The cyborg's dilemma: progressive embodiment in virtual environments. *Journal of Computer-Mediated Communication*, *3*(2), JCMC324. https://doi.org/10.1111/j.1083-6101.1997.tb00070.x

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and Virtual Environments*, *12*(5), 456–480. https://doi.org/10.1162/105474603322761270

Blaney, J., & Stout, J. (2017). Examining the relationship between introductory computing course experiences, self-efficacy, and belonging among first-generation college women. *Association for Computing Machinery: Proceedings of SIGCSE 2017*.

Bordini, R. A., & Korn, O. (2020). *A mobile app to combat loneliness and social isolation among university students.* (MobileHCI '20: 22nd International Conference on Human-

Computer Interaction with Mobile Devices and Services). ACM. https://doi.org/10.1145/3406324.3409260

Bosch, N., Crues, R. W., Henricks, G. M., Perry, M., Angrave, L., Shaik, N., Bhat, S., & Anderson, C. J. (2018). *Modeling key differences in underrepresented students' interactions with an online STEM course* (TechMindSociety '18: Proceedings of the Technology, Mind, and Society). ACM. https://doi.org/10.1145/3183654.3183681

Boston, W. E., Ice, P., & Gibson, A. M. (2011). *Comprehensive assessment of student retention in online learning environments* (EJ921846). ERIC. https://eric.ed.gov/?id=EJ921846

Boyer, K. E., Thomas, E. N., Rorrer, A. S., Cooper, D., & Vouk, M. A. (2010). *Increasing technical excellence, leadership and commitment of computing students through identity-based mentoring* (SIGCSE '10: Proceedings of the 41st ACM technical symposium on Computer science education). ACM. https://doi.org/10.1145/1734263.1734320

Bullingham, L., & Vasconcelos, A. C. (2013). 'The presentation of self in the online world': Goffman and the study of online identities. *Journal of Information Science*, *39*(1), 101–112. https://doi.org/10.1177/0165551512470051

Bylieva, D., Hong, J.-C., Lobatyuk, V., & Nam, T. (2021). Self-regulation in e-learning environment. *Education Sciences*, *11*(12), 785. https://doi.org/10.3390/educsci11120785

Camp, T., Zweben, S., Buell, D., & Stout, J. (2016). Booming Enrollments: Survey Data. *SIGCSE '16: Proceedings of the 47th ACM Technical Symposium on Computing Science Education*, *February*, 398–399. https://doi.org/10.1145/2839509.2844663

Carbonaro, M., Rex, M., & Chambers, J. (2004). Using Lego robotics in a project-based learning environment. *The Interactive Multimedia Electronic Journal of Computer-Enhanced Learning*, *6*(1). Retrieved January 26, 2023, from http://www.imej.wfu.edu/articles/2004/1/02/printver.asp

Charitsis, C., Piech, C., & Mitchell, J. C. (2022). *Feedback on program development process for CS1 students* (SIGCSE 2022: Proceedings of the 53rd ACM Technical Symposium

on Computer Science Education V. 2). ACM. https://doi.org/10.1145/3478432.3499062

Charmaz, K., Harris, S. R., & Irvine, L. (2019). *The social self and everyday life: Understanding the world through symbolic interactionism* (1st ed.). Wiley-Blackwell.

Chen, J., Wang, M., Kirschner, P. A., & Tsai, C.-C. (2018). The role of collaboration, computer use, learning environments, and supporting strategies in cscl: A meta-analysis. *Review of Educational Research, 88*(6), 799–843. https://doi.org/10.3102/0034654318791584

Chen, R., Davison, R. M., & Ou, C. (2020). A symbolic interactionism perspective of using social media for personal and business communication. *International Journal of Information Management*, *51*, 102022. https://doi.org/10.1016/j.ijinfomgt.2019.10.007

Chen, X. (2013). *STEM attrition: College students' paths into and out of STEM fields. statistical analysis report. NCES 2014-001* (ED544470). ERIC. https://eric.ed.gov/?id=ED544470

Chiu, T. F., Lin, T.-J., & Lonka, K. (2021). Motivating online learning: The challenges of Covid-19 and beyond. *The Asia-Pacific Education Researcher*, *30*(3), 187–190. https://doi.org/10.1007/s40299-021-00566-w

Chiyaka, E. T., Sithole, A., Manyanga, F., McCarthy, P., & Bucklein, B. K. (2016). *Institutional characteristics and student retention: What integrated postsecondary education data reveals about online learning* (EJ1106655). ERIC. https://eric.ed.gov/?id=EJ1106655

Cho, M.-H., & Tobias, S. (2016). Should instructors require discussion in online courses Effects of online discussion on community of inquiry, learner time, satisfaction, and achievement. *International Review of Research in Open and Distributed Learning*, *17*(2), 123–140. https://files.eric.ed.gov/fulltext/EJ1093637.pdf

Cleary, Y. (2020). Fostering communities of inquiry and connectivism in online technical communication programs and courses. *Journal of Technical Writing and Communication*, *51*(1), 11–30. https://doi.org/10.1177/0047281620977138

Cliff, N. (1993). Dominance statistics: Ordinal analyses to answer ordinal questions. *Psychological Bulletin*, *114*(3), 494–509. https://doi.org/10.1037/0033-2909.114.3.494

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Lawrence Erlbaum Associates.

Cohon, J., & Hambrusch, S. (2018). *Assessing and responding to the growth of computer science undergraduate enrollments*. National Academies Press. https://doi.org/10.17226/24926

Cortese, J., & Seo, M. (2012). The role of social presence in opinion expression during FtF and CMC discussions. *Communication Research*, *29*, 44–53. https://doi.org/10.1080/08824096.2011.639913

Coulter, K. S., & Coulter, R. A. (2003). The effects of industry knowledge on the development of trust in service relationships. *International journal of research in marketing*, *20*(1), 31–43. https://doi.org/10.1016/S0167-8116(02)00120-9

CRA. (2022). *Center for Evaluating the Research Pipeline*. Computing Research Association. Retrieved August 20, 2022, from https://cra.org/cerp/

Creswell, J. W., & Creswell, J. (2018). *Research design: qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.

Cronbach, L. J. (1951). Coefficient Alpha and the internal structure of tests. *Psychometrika*, *16*, 297–334. https://doi.org/10.1007/BF02310555

Crues, R., Henricks, G. M., Perry, M., Bhat, S., Anderson, C. J., Shaik, N., & Angrave, L. (2018). How do gender, learning goals, and forum participation predict persistence in a computer science mooc? *ACM Transactions on Computing Education*, *18*(4), 1–14. https://doi.org/10.1145/3152892

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Manage. Sci.*, *32*, 554–571. https://doi.org/10.1287/mnsc.32.5.554

De Freitas, S., Morgan, J., & Gibson, D. (2015). Will moocs transform learning and teaching in higher education? engagement and course retention in online learning provision.

British Journal of Educational Technology, *46*(3), 455–471. https://doi.org/10.1111/bjet.12268

De Meyrick, J. (2005). Approval procedures and passive consent considerations in research among young people. *Health Education*, *105*(4), 249–258. https://doi.org/10.1108/09654280510602471

DeClue, T. (2009). A theory of attrition in computer science education which explores the effect of learning theory, gender, and context. *Journal of Computing Sciences in Colleges*, *24*(5), 115–121.

Delgaty, L. (2019). Transactional distance theory: A critical view of the theoretical and pedagogical underpinnings of e-learning. In D. Cvetković (Ed.), *Interactive multimedia - multimedia production and digital storytelling*. IntechOpen. https://doi.org/10.5772/intechopen.81357

Derks, D., Bos, A. E., & Grumbkow, J. (2007). Emoticons and social interaction on the internet: The importance of social context. *Computers in Human Behavior*, *23*(1), 842–849. https://doi.org/10.1016/j.chb.2004.11.013

DeVellis, R. F. (2016). *Scale development: Theory and applications (applied social research methods)* (Fourth ed.). SAGE Publications, Inc.

Devi, K. (2019). Constructivist approach to learning based on the concepts of Jean Piaget and Lev Vygotsky. *Journal of Indian Education*, *XLIV*(4), 5–19. https://n20.ncert.org.in/pdf/publication/journalsandperiodicals/journalofindianeducation/JIE-FEB2019.pdf#page=7

Dewey, J. (1980, 1938). *Logic: The theory of inquiry*. Irvington Pub.

Dimitrios, T., & Fountouki, A. (2018). Limitations and delimitations in the research process. *Perioperative Nursing-Quarterly scientific, online official journal of GORNA*, *7*(3), 155–163. https://doi.org/10.5281/zenodo.2552022

Doak, M. (2022, March 7). *Online learning can lead to increased success for minority students in higher education*. EdTech: Technology Solutions That Drive Education. Retrieved

March 2, 2023, from https://edtechmagazine.com/higher/article/2022/03/online-learning-can-lead-increased-success-minority-students-higher-education

Donohoo, J. (2018). Collective teacher efficacy research: Productive patterns of behaviour and other positive consequences. *Journal of Educational Change*, *19*(3), 323–345. https://doi.org/10.1007/s10833-018-9319-2

Downes, S. (2019). *Recent work in connectivism* (EJ1245809). ERIC. https://eric.ed.gov/?id=EJ1245809

Downes, S. (2022). *Connectivism* (EJ1350294). ERIC. https://eric.ed.gov/?id=EJ1350294

Drost, E. (2011). Validity and reliability in social science research. *Education Research and perspectives*, *38*(1), 105–123.

Elliott, K. M., & Shin, D. (2002). Student satisfaction: An alternative approach to assessing this important concept. *Journal of Higher Education Policy and Management*, *24*(2), 197–209. https://doi.org/10.1080/1360080022000013518

Ellis, P. D. (2012). *The essential guide to effect sizes*. Cambridge Core. https://doi.org/10.1017/CBO9780511761676

Falloon, G. (2011). *Making the connection: Moore's theory of transactional distance and its relevance to the use of a virtual classroom in postgraduate online teacher education* (EJ918904). ERIC. https://eric.ed.gov/?id=EJ918904

Farag, W., Ali, S., & Ghani, I. (2019). Comparing Student Satisfaction and Perception of Effectiveness in Two Different Online Computer Science Courses. *Proceedings of the International Conference on The Future of Education*, *13*. https://conference.pixel-online.net/library_scheda.php?id_abs=3993

Field, A. (2013). *Discovering Statistics Using SPSS* (4th ed.). SAGE.

Fiock, H. (2020). Designing a community of inquiry in online courses. *International Review of Research in Open and Distributed Learning*, *21*(1), 134–152. https://files.eric.ed.gov/fulltext/EJ1240692.pdf

Fisher, L. M. (2016). Booming enrollments. *Communications of the ACM*, *59*(7), 17–18. https://doi.org/10.1145/2933418

Fogg, B., & Tseng, H. (1999). *The elements of computer credibility*. Proceedings of the SIGCHI conference on Human Factors in Computing Systems (New York, NY: ACM). http://credibility.stanford.edu/pdf/p80-fogg.pdf

Forment, M. A. (2011). A social constructionist approach to learning communities. In M. A. Forment (Ed.), *Open source for knowledge and learning management* (pp. 369–381). IGI Global. https://doi.org/10.4018/978-1-59904-117-9.ch013

Francescato, D., Porcelli, R., Mebane, M., Cuddetta, M., Klobas, J., & Renzi, P. (2006). Evaluation of the efficacy of collaborative learning in face-to-face and computer-supported university contexts. *Computers in Human Behavior*, *22*(2), 163–176. https://doi.org/10.1016/j.chb.2005.03.001

Garrison, D. (2012). Theoretical foundations and epistemological insights of the community of inquiry. In Z. Akyol & D. Garrison (Eds.), *Educational communities of inquiry* (pp. 1–11). IGI Global. https://doi.org/10.4018/978-1-4666-2110-7.ch001

Garrison, D., Anderson, T., & Archer, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, *2*(2-3), 87–105. https://doi.org/10.1016/s1096-7516(00)00016-6

Giossos, Y., Koutsouba, M., Lionarakis, A., & Skavantzos, K. (2009). Reconsidering Moore's transactional distance theory. *The European Journal of Open, Distance and E-Learning*, *12*, 1–6. https://eric.ed.gov/?id=EJ911768

Goffman, E. (1959). *The presentation of self in everyday life* (1st ed.). Anchor.

Gokool-Ramdoo, S. (2008). Beyond the theoretical impasse: Extending the applications of transactional distance education theory. *The International Review of Research in Open and Distributed Learning*, *9*(3), 1–17. https://files.eric.ed.gov/fulltext/EJ815762.pdf

González Miy, D., & Herrera Díaz, L. (2015). Tracking the path of communities of inquiry in tefl: A literature review. *HOW*, *22*(1), 80–94. https://doi.org/10.19183/how.22.1.83

Gorsky, P., & Caspi, A. (2005). A critical analysis of transactional distance theory. *Quarterly Review of Distance Education*, *6*(1), 1–11. https://eric.ed.gov/?id=EJ874984

Gourlay, L., Rodríguez-Illera, J., Barberà, E., Bali, M., Gachago, D., Pallitt, N., Jones, C., Bayne, S., Hansen, S., Hrastinski, S., Jaldemark, J., Themelis, C., Pischetola, M., Dirckinck-Holmfeld, L., Matthews, A., Gulson, K. N., Lee, K., Bligh, B., Thibaut, P.,...Knox, J. (2021). Networked learning in 2021: A community definition. *Postdigital Science and Education*, *3*(2), 326–369. https://doi.org/10.1007/s42438-021-00222-y

Grant, C., & Osanloo, A. (2014). *Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house"* (EJ1058505). ERIC. https://eric.ed.gov/?id=EJ1058505

Gray, J. A., & DiLoreto, M. (2016). *The effects of student engagement, student satisfaction, and perceived learning in online learning environments* (EJ1103654). ERIC. https://eric.ed.gov/?id=EJ1103654

Gray, S., Edwards, S., Lewandowski, G., & Shende, A. (2005). Improving student programming skills by developing program comprehension abilities: panel discussion. *Journal of Computing Sciences in Colleges*, *20*(3), 235–237. https://doi.org/10.5555/1040196.1040227

Gray, S., Edwards, S., Lewandowski, G., & Shende, A. (2005b). Improving student programming skills by developing program comprehension abilities: panel discussion. *Journal of Computing Sciences in Colleges*, *20*(3), 235–237. https://doi.org/10.5555/1040196.1040227

Grøtan, K., Sund, E. R., & Bjerkeset, O. (2019). Mental health, academic self-efficacy and study progress among college students – the shot study, Norway. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.00045

Gumbo, M. T. (2016, February 25). *The question of technology education: a pertinent issue* [Inaugural Lecture]. UNISA institutional repository. http://hdl.handle.net/10500/20945

Gumbo, M. T. (2017). Alternative knowledge systems. In Williams, J. & Stables, K. (Ed.), *Critique in Design and Technology Education* (pp. 87–105). Springer Singapore. https://doi.org/10.1007/978-981-10-3106-9_6

Gumbo, M. T. (2020). Indigenising technological pedagogical content knowledge in open distance learning. *Africa Education Review*, *17*(4), 72–86. https://doi.org/10.1080/18146627.2020.1868073

Gunawardena, C. N. (1995). Social presence theory and implications for interaction and collaborative learning in computer conferences. *International Journal of Educational Telecommunications*, *1*(2/3), 147–166. https://www.learntechlib.org/p/15156/

Gunawardena, C. (2020). Culturally inclusive online learning for capacity development projects in international contexts. *Journal of Learning for Development*, *7*(1), 5–30. https://jl4d.org/index.php/ejl4d/article/view/403

Gunawardena, C. N., Hermans, M., Sanchez, D., Richmond, C., Bohley, M., & Tuttle, R. (2009). A theoretical framework for building online communities of practice with social networking tools. *Educational Media International*, *46*(1), 3–16. https://doi.org/10.1080/09523980802588626

Gunawardena, C. N., & Zittle, F. J. (1997). Social presence as a predictor of satisfaction within a computer-mediated conferencing environment. *American Journal of Distance Education*, *11*(3), 8–26. https://doi.org/10.1080/08923649709526970

Hadi, M. E., Atiqoh, K. S. N., & Kadir. (2021). Using Scratch program through project based learning: a development research during pandemic Covid-19. *9th International Conference on Cyber and IT Service Management (CITSM)*, 1–5. https://doi.org/10.1109/CITSM52892.2021.9588856

Hanover College. (2016). *Reliability Analysis*. SPSS statistics exercises. Retrieved February 27, 2023, from https://vault.hanover.edu/~altermattw/courses/220/spss/reliability/reliability-2.html

Hanusz, Z., & Tarasińska, J. (2015). Normalization of the kolmogorov–smirnov and shapiro–wilk tests of normality. *Biometrical Letters*, *52*(2), 85–93. https://doi.org/10.1515/bile-2015-0008

Harrison, D., Rowland, S., Wood, G., Bakewell, L., Petridis, I., Long, K., Valiseeuiou, K., Barnett, J., Barreto, M., Wilson, M., Lawson, S., & Vines, J. (2022). *Designing technology-mediated peer support for postgraduate research students at risk of*

loneliness and isolation (ACM Transactions on Computer-Human Interaction). https://doi.org/10.1145/3534961

Hassanein, K., & Head, M. (2007). Manipulating perceived social presence through the web interface and its impact on attitude towards online shopping. *International Journal of Human-Computer Studies*, *65*(8), 689–708. https://doi.org/10.1016/j.ijhcs.2006.11.018

Hayat, A., Shateri, K., Amini, M., & Shokrpour, N. (2020). Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: A structural equation model. *BMC Medical Education*, *20*(1). https://doi.org/10.1186/s12909-020-01995-9

Hehir, E., Zeller, M., Luckhurst, J., & Chandler, T. (2021). Developing student connectedness under remote learning using digital resources: A systematic review. *Education and Information Technologies*, *26*(5), 6531–6548. https://doi.org/10.1007/s10639-021-10577-1

Herzberg, F. (2017). *Motivation to work* (1959 reprint, 1st ed.). Taylor & Francis.

Herzberg, F., Mausner, B., & Snyderman, B. B. (1959). *The motivation to work* (2nd ed.). John Wiley & Sons.

Holder, D. (2005). Examining the impact of learning communities on motivation. *Faculty Publications and Presentations*, *120*. https://digitalcommons.liberty.edu/cgi/viewcontent.cgi?article=1137&context=educ_fac_pubs

House, R. J. (1971). A path goal theory of leader effectiveness. *Administrative Science Quarterly*, *16*(3), 321. https://doi.org/10.2307/2391905

House, R. J. (1996). Path-goal theory of leadership: Lessons, legacy, and a reformulated theory. *The Leadership Quarterly*, *7*(3), 323–352. https://doi.org/10.1016/s1048-9843(96)90024-7

House, R. J. (1996). Path-goal theory of leadership: Lessons, legacy, and a reformulated theory. *The Leadership Quarterly*, *7*(3), 323–352. https://doi.org/10.1016/s1048-9843(96)90024-7

Jahng, M., & Littau, J. (2015). Interacting is believing. *Journalism & Mass Communication Quarterly*, *93*(1), 38–58. https://doi.org/10.1177/1077699015606680

James, S., Swan, K., & Daston, C. (2016). *Retention, progression and the taking of online courses* (EJ1105922). ERIC. https://eric.ed.gov/?id=EJ1105922

Jaradat, S. A., & Ajlouni, A. O. (2020). *Social presence and self-efficacy in relation to student satisfaction in online learning setting: A predictive study* (EJ1279096). ERIC. https://eric.ed.gov/?id=EJ1279096

Johnson, D. W., & Johnson, R. T. (2014). Cooperative learning in 21st century. *Anales de Psicología*, *30*(3), 841–851. https://doi.org/10.6018/analesps.30.3.201241

Katz, N., Lazer, D., Arrow, H., & Contractor, N. (2004). Network theory and small groups. *Small Group Research*, *35*(3), 307–332. https://doi.org/10.1177/1046496404264941

Keely, S., Luxton-Reilly, A., Ajanovski, V., Fouth, E., Gonsalvez, C., Leinonen, J., Parkinson, J., Poole, M., & Thota, N. (2019). Pass rates in introductory programming and in other STEM disciplines. *Proceedings of the Working Group Reports on Innovation and Technology in Computer Science Education. ITiCSE '19: Innovation and Technology in Computer Science Education*, *2019*, 53–71. https://doi.org/10.1145/3344429.3372502

Kehrwald, B. (2008). Understanding social presence in text-based online learning environments. *Distance Education*, *29*(1), 89–106. https://doi.org/10.1080/01587910802004860

Kelley, T. L. (1927). *Interpretation of Educational Measurements*. World Book Company.

Khatun, N. (2021). Applications of normality test in statistical analysis. *Open Journal of Statistics*, *11*(01), 113–122. https://doi.org/10.4236/ojs.2021.111006

Kim, H.-S., & Sundar, S. S. (2014). Can online buddies and bandwagon cues enhance user participation in online health communities? *Computers in Human Behavior*, *37*, 319–333. https://doi.org/10.1016/j.chb.2014.04.039

Kim, J., Kwon, Y., & Cho, D. (2011). *Investigating factors that influence social presence and learning outcomes in distance higher education* (EJ925841). ERIC. https://eric.ed.gov/?id=EJ925841

Klowait, N. (2019). Interactionism in the age of ubiquitous telecommunication. *Information, Communication & Society*, *22*(5), 605–621. https://doi.org/10.1080/1369118x.2019.1566487

Kolmogorov-Smirnov test. (2008). In Y. Dodge (Ed.), *The concise encyclopedia of statistics* (pp. 283–287). Springer New York. https://doi.org/10.1007/978-0-387-32833-1_214

Kop, R. (2011). The challenges to connectivist learning on open online networks: Learning experiences during a massive open online course. *The International Review of Research in Open and Distributed Learning*, *12*(3), 19. https://doi.org/10.19173/irrodl.v12i3.882

Kreijns, K., Kirschner, P. A., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environment. *Journal of Education Technology & Society*, *5*(1), 8–22. http://www.jstor.org/stable/jeductechsoci.5.1.8

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior*, *19*, 335–353. http://www.elsevier.com/locate/comphumbeh

Kreijns, K., Kirschner, P. A., Jochems, W., & Van Buuren, H. (2011). Measuring perceived social presence in distributed learning groups. *Education and Information Technologies*, *16*(4), 365–381. https://doi.org/10.1007/s10639-010-9135-7

Kreijns, K., Van Acker, F., Vermeulen, M., & Van Buuren, H. (2013). What stimulates teachers to integrate ict in their pedagogical practices? the use of digital learning materials in education. *Computers in Human Behavior*, *29*(1), 217–225. https://doi.org/10.1016/j.chb.2012.08.008

Kreijns, K., Van Acker, F., Vermeulen, M., & Van Buuren, H. (2014). Community of inquiry: Social presence revisited. *E-Learning and Digital Media*, *11*(1), 5–18. https://doi.org/10.2304/elea.2014.11.1.5

Kreijns, K., Xu, K., & Weidlich, J. (2021). Social presence: Conceptualization and measurement. *Educational Psychology Review*, *34*(1), 139–170. https://doi.org/10.1007/s10648-021-09623-8

Kricorian, K., Seu, M., Lopez, D., Ureta, E., & Equils, O. (2020). Factors influencing participation of underrepresented students in STEM fields: Matched mentors and mindsets. *International Journal of STEM Education*, *7*(1). https://doi.org/10.1186/s40594-020-00219-2

Laal, M., & Ghodsi, S. (2012). Benefits of collaborative learning. *Procedia - Social and Behavioral Sciences*, *31*, 486–490. https://doi.org/10.1016/j.sbspro.2011.12.091

Lakhal, S., Khechine, H., & Mukamurera, J. (2021). Explaining persistence in online courses in higher education: a difference-in-differences analysis. *International Journal of Educational Technology in Higher Education*, *18*(1). https://doi.org/10.1186/s41239-021-00251-4

LaRoche, L. S. (2009). *Sustaining a student program through collaboration and communication* (SIGUCCS '09: Proceedings of the 37th annual ACM SIGUCCS fall conference: communication and collaboration). ACM. https://doi.org/10.1145/1629501.1629505

Larsen, K. R., & Bong, C. H. (2016). A tool for addressing construct identity in literature reviews and meta-analyses. *MIS Quarterly*, *40*(3), 529–551. https://doi.org/10.25300/MISQ/2016/40.3.01

Latour, B. (1988). *Science in action: How to follow scientists and engineers through society* (Revised ed.). Harvard University Press.

Latour, B. (1991). *We have never been modern* (1st ed.). Harvard University Press.

Latour, B. (1999). *Pandora's hope: Essays on the reality of science studies* (1st ed.). Harvard University Press.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory (Clarendon Lectures in Management Studies)* (1st ed.). Oxford University Press.

Lee, H.-M., Long, J., & Mehta, M. R. (2011). *Designing an E-mentoring application for facebook* (SIGMIS-CPR '11: Proceedings of the 49th SIGMIS annual conference on Computer personnel research). ACM. https://doi.org/10.1145/1982143.1982175

Lee, K. M., Jung, Y., Kim, J., & Kim, S. R. (2006). Are physically embodied social agents better than disembodied social agents?: The effects of physical embodiment, tactile interaction, and people's loneliness in human–robot interaction. *International Journal of Human-Computer Studies*, *64*(10), 926–973. https://doi.org/10.1016/j.ijhcs.2006.05.002

Lee, K. M., & Nass, C. (2004). The multiple source effect and synthesized speech: doubly-disembodied language as a conceptual framework. *Human Communication Research*, *30*(2), 187–207. https://doi.org/10.1111/j.1468-2958.2004.tb00730.x

Lehtinen, T., Lukkarinen, A., & Haaranen, L. (2021). *Students struggle to explain their own program code* (ITiCSE '21: Proceedings of the 26th ACM Conference on Innovation and Technology in Computer Science Education). ACM. https://doi.org/10.1145/3430665.3456322

Leigh, J., Hiscock, J., McConnell, A., Haynes, C., Caltagirone, C., Kieffer, M., Draper, E., Slater, A., Krbek, L., Hutchins, K., Watkins, D., & Busschaert, N. (2022). Challenges for women and marginalised groups. *Women in supramolecular chemistry* (pp. 52–68). Policy Press. https://doi.org/10.51952/9781447362395.ch004

Lewis, C., Camp, T., Horton, T., Reed, D., & Tamer, B. (2021). How student surveys drive change: using the Data Buddies department report from the Computing Research Association. *SIGCSE '21: Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, *March*, 136–137. https://doi.org/10.1145/3408877.3432568

Li, F. (2022). “Are you there?”: Teaching presence and interaction in large online literature classes. *Asian-Pacific Journal of Second and Foreign Language Education*, *7*(1). https://doi.org/10.1186/s40862-022-00180-3

Lippke, S. (2020). Self-efficacy theory. In Zeigler-Hill,V. & Shackelford, T. (Ed.), *Encyclopedia of personality and individual differences* (pp. 4722–4727). Springer International Publishing. https://doi.org/10.1007/978-3-319-24612-3_1167

Liu, S., Gomez, J., & Yen, C.-J. (2009). Community college online course retention and final grade: predictability of social presence. *Journal of Interactive Online Learning*, *8*(2), 165–182. https://digitalcommons.odu.edu/efl_fac_pubs/10

Liu, X. (2019). A probabilistic explanation of pearson's correlation. *Teaching Statistics*, *41*(3), 115–117. https://doi.org/10.1111/test.12204

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational Behavior and Human Performance*, *3*(2), 157–189. https://doi.org/10.1016/0030-5073(68)90004-4

Locke, E. A., & Latham, G. P. (1989). A theory of goal setting and task performance. *The Academy of Management Review*, *16*(2), 480. https://doi.org/10.2307/258875

Lopez, P., & Hassoun, S. (2022, January). *Expanding the pipeline: recruiting and retaining computing students through research experiences for undergraduates*. Computing Research Association. Retrieved August 28, 2022, from https://cra.org/crn/2022/01/expanding-the-pipeline-recruiting-and-retaining-computing-students-through-research-experiences-for-undergraduates/

Lowenthal, P., & Dunlap, J. (2019). Live synchronous web meetings in asynchronous online courses: Reconceptualizing virtual office hours. *Online Learning*, *23*(1), 81–102. https://olj.onlinelearningconsortium.org/index.php/olj/article/download/1285/345

Lowenthal, P. R. (2011). The evolution and influence of social presence theory on online learning. In Dasgupta, S. (Ed.), *Social computing: concepts, methodologies, tools, and applications* (pp. 113–128). IGI Global. https://doi.org/10.4018/978-1-60566-984-7.ch010

Lowenthal, P. R., & Dennen, V. P. (2017). Social presence, identity, and online learning: Research development and needs. *Distance Education*, *38*(2), 137–140. https://doi.org/10.1080/01587919.2017.1335172

Lowenthal, P. R., & Dunlap, J. C. (2010). From pixel on a screen to real person in your students' lives: Establishing social presence using digital storytelling. *The Internet and Higher Education*, *13*(1-2), 70–72. https://doi.org/10.1016/j.iheduc.2009.10.004

Lowenthal, P. R., & Snelson, C. (2017). In search of a better understanding of social presence: an investigation into how researchers define social presence. *Distance Education*, *38*(2), 141–159. https://doi.org/10.1080/01587919.2017.1324727

Luse, A., Mennecke, B., & Townsend, A. (2012). Selecting a research topic: a framework for doctoral students. *International Journal of Doctoral Studies*, *7*(1), 143–152. https://doi.org/10.28945/1572

Makoe, M., & Shandu-Phetla, T. P. (2019). *Using mobile-based social media to facilitate interaction and build communities through the lens of ubuntu in distance education* (EJ1222913). ERIC. https://eric.ed.gov/?id=EJ1222913

Massey, F. (1951a). The Kolmogorov-Smirnov test for goodness of fit. *Journal of the American statistical Association*, *46*(253), 68–78.

Massey, F. (1951b). The Kolmogorov-Smirnov test for goodness of fit. *Journal of the American Statistical Association*, *46*(253), 68–78. https://doi.org/10.2307/2280095

Mattar, J. (2018). Constructivism and connectivism in education technology: Active, situated, authentic, experiential, and anchored learning. *RIED. Revista Iberoamericana de Educación a Distancia*, *21*(2), 201. https://doi.org/10.5944/ried.21.2.20055

Mayr, A., & Oppl, S. (2022). Higher education at the margins – success criteria for blended learning systems for marginalized communities. *Education and Information Technologies*. https://doi.org/10.1007/s10639-022-11282-3

McDowell, C., Werner, L., Bullock, H., & Fernald, J. (2002). *The effects of pair-programming on performance in an introductory programming course* (SIGCSE '02: Proceedings of the 33rd SIGCSE technical symposium on Computer science education). ACM. https://doi.org/10.1145/563340.563353

McInnerney, J. M., & Roberts, T. S. (2004). Online learning: Social interaction and the creation of a sense of community on JSTOR. *Educational Technology & Society*, *7*(3), 73–81. https://www.jstor.org/stable/jeductechsoci.7.3.73

McMillan, D. W., & Chavis, D. M. (1986). Sense of community: A definition and theory. *Journal of Community Psychology*, *14*(1), 6–23. https://doi.org/10.1002/1520-6629(198601)14:13.0.co;2-i

McVeigh, R. (2020). The body in mind: Mead's embodied cognition. *Symbolic Interaction*, *43*(3), 493–513. https://doi.org/10.1002/symb.476

Melrose, S., Park, C., & Perry, B. (2014). *Teaching health professionals online: Frameworks and strategies*. Athabasca University Press.

Miao, J., & Ma, L. (2022). Students' online interaction, self-regulation, and learning engagement in higher education: The importance of social presence to online learning. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.815220

Miles, M. L., Brockman, A. J., & Naphan-Kingery, D. E. (2020). Invalidated identities: The disconfirming effects of racial microaggressions on black doctoral students in STEM. *Journal of Research in Science Teaching*, *57*(10), 1608–1631. https://doi.org/10.1002/tea.21646

Miller, A., & Kay, J. (2002). *A mentor program in CS1* (ITiCSE '02: Proceedings of the 7th annual conference on Innovation and technology in computer science education). https://doi.org/10.1145/544414.544420

Miner, J. B. (2005). *Organizational behavior 1: Essential theories of motivation and leadership* (1st ed.). Routledge.

Moallem, M. (2015). The impact of synchronous and asynchronous communication tools on learner self-regulation, social presence, immediacy, intimacy and satisfaction In collaborative online learning. *The Online Journal of Distance Education and e-Learning*, *3*(3), 55–77. https://www.tojdel.net/journals/tojdel/articles/v03i03/v03i03-08.pdf

Moodle. (2018, December 5). *Philosophy*. moodledocs. Retrieved January 26, 2023, from https://docs.moodle.org/401/en/Philosophy

Moore, M. (1973). Toward a theory of independent learning and teaching. *The Journal of Higher Education*, *44*(9), 661–679. https://doi.org/10.1080/00221546.1973.11776906

Moore, M. G. (1997). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 22–38). Routledge. http://www.c3l.uni-oldenburg.de/cde/found/moore93.pdf

Mykota, D. (2017). *The impact of learner characteristics on the multi-dimensional construct of social presence* (EJ1137812). ERIC. https://eric.ed.gov/?id=EJ1137812

Narayanan, S., Cunningham, K., Arteaga, S., Welch, W. J., Maxwell, L., Chawinga, Z., & Su, B. (2018). *Upward mobility for underrepresented students: a model for a cohort-based bachelor's degree in computer science* (SIGCSE '18: Proceedings of the 49th ACM Technical Symposium on Computer Science Education). ACM. https://doi.org/10.1145/3159450.3159551

Nasir, M. K. & Khalid, M. (2020). *The influence of social presence on students' satisfaction toward online course* (EJ1285218). ERIC. https://eric.ed.gov/?id=EJ1285218

National Center for Women & Information Technology (NCWIT). (2021). *By the numbers: women in computing*. https://www.ncwit.org/by-the-numbers-women-in-computing

Neto, V., Rolim, V., Pinheiro, A., Lins, R., Gasevic, D., & Mello, R. (2021). Automatic content analysis of online discussions for cognitive presence: A study of the generalizability across educational contexts. *IEEE Transactions on Learning Technologies*, *14*(3), 299–312. https://doi.org/10.1109/tlt.2021.3083178

Neureiter, K., Vollmer, J., Gerwert Vaz de Carvalho, R. L., & Tscheligi, M. (2017). *Starting up an e-mentoring relationship: a user study* (C&T '17: Proceedings of the 8th International Conference on Communities and Technologies). https://doi.org/10.1145/3083671.3083692

Ngulube, P., Mathipa, E. R., & Gumbo, M. T. (2015). Theoretical and conceptual framework in the social sciences. In E. R. Mathipa & M. Gumbo (Eds.), *Addressing research*

challenges: Making headway in developing researchers (pp. 43–66). Mosala-MASEDI Publishers & Booksellers. https://doi.org/10.13140/RG.2.1.3210.7680

Nosek, J. T. (1998). The case for collaborative programming. *Communications of the ACM*, *41*(3), 105–108. https://doi.org/10.1145/272287.272333

Ntuli, S., & Gumbo, M. T. (2019). Tutors' views on the integrated tutor model in open distance learning. *Perspectives in Education*, *37*(2), 53–66. https://doi.org/10.18820/2519593x/pie.v37i2.4

Ogundimu, E. O., & Hutton, J. L. (2015). A sample selection model with skew-normal distribution. *Scandinavian Journal of Statistics*, *43*(1), 172–190. https://doi.org/10.1111/sjos.12171

Oh, C. S., Bailenson, J. N., & Welch, G. F. (2018). A systematic review of social presence: definition, antecedents, and implications. *Frontiers in Robotics and AI*, *15*, 1–35. https://doi.org/10.3389/frobt.2018.00114

Olivier, J. (2021). Online access and resources for open self-directed learning in Africa. In Burgos, D. & Olivier, J. (Ed.), *Radical solutions for education in Africa* (pp. 1–16). Springer Singapore. https://doi.org/10.1007/978-981-16-4099-5_1

Olson, S. (2012). *Report to the president engage to excel: producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Executive Office of the President President's Council of Advisors on Science and Technology. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Orcher, L. (2014). *Conducting research: social and behavioral science methods* (2nd ed.). Routledge. https://doi.org/10.4324/9781315266626

Oyarzun, B., Stefaniak, J., Bol, L., & Morrison, G. R. (2018). *Effects of learner-to-learner interactions on social presence, achievement and satisfaction* (EJ1175660). ERIC. https://eric.ed.gov/?id=EJ1175660

Öztok, M., & Kehrwald, B. A. (2017). Social presence reconsidered: Moving beyond, going back, or killing social presence. *Distance Education*, *38*(2), 259–266. https://doi.org/10.1080/01587919.2017.1322456

Pando, V. F. (2018). Tendencias didácticas de la educación virtual: Un enfoque interpretativo. *Propósitos y Representaciones*, *6*(1). https://doi.org/10.20511/pyr2018.v6n1.167

Papert, S. (1980). *Mind storms: Children, computers, and powerful ideas* (First ed.). Basic.

Papert, S. A. (1994). *The children's machine: Rethinking school in the age of the computer* (Revised ed.). Basic Books.

Papert, S., & Harel, I. (1991). *Situating constructionism* (Constructionism). MIT Media Lab. https://web.media.mit.edu/~calla/web_comunidad/Reading-En/situating_constructionism.pdf

Pass, S. (2004). *Parallel paths to constructivism: Jean Piaget and Lev Vygotsky*. Information Age Publishing.

Piaget, J. (1954). *The construction of reality in the child*. Basic Books. https://doi.org/10.1037/11168-000

Poth, R. D. (2018). Social presence in online learning. In M. Marmon (Ed.), *Enhancing social presence in online environments* (pp. 88–116). IGI Global. https://doi.org/10.4018/978-1-5225-3229-3.ch005

Price, P. C., Jhangiani, R., Chiang, I.-C. A., & Cutler, C. (2013). 6.2 Correlational Research. In *Research methods in psychology* (3rd ed.). PB Pressbooks. https://opentext.wsu.edu/carriecuttler/chapter/correlational-research/

Rallis, S. F. (2018). Conceptual framework. In B. B. Frey (Ed.), *The SAGE encyclopedia of educational research, measurement, and evaluation* (pp. 355–356). SAGE Publications. https://doi.org/10.4135/9781506326139.n134

Ratan, R. A., & Hasler, B. (2009). *Self-presence standardized: Introducing the self-presence questionnaire (SPQ)*. Proceedings of the 12th Annual International Workshop on Presence (Los Angeles, CA). https://www.runi.ac.il/media/j5faqyzo/selfpresencestandardized.pdf

Rea, L. M., & Parker, R. A. (2014). *Designing and conducting survey research: A comprehensive guide*, (4th ed.). Jossey-Bass.

Richardson, J. C., Besser, E., Koehler, A., Lim, J., & Strait, M. (2016). Instructors' perceptions of instructor presence in online learning environments. *The International Review of Research in Open and Distributed Learning*, *17*(4). https://doi.org/10.19173/irrodl.v17i4.2330

Richardson, J. C., & Swan, K. (2019). Examining social presence in online courses in relation to students' perceived learning and satisfaction. *Online Learning*, *7*(1). https://doi.org/10.24059/olj.v7i1.1864

Rizkallah, E. G., & Seitz, V. (2017). Understanding student motivation: A key to retention in higher education. *Scientific Annals of Economics and Business*, *64*(1), 45–57. https://doi.org/10.1515/saeb-2017-0004

Rob, M., & Rob, F. (2018). Dilemma between constructivism and constructionism. *Journal of International Education in Business*, *11*(2), 273–290. https://doi.org/10.1108/jieb-01-2018-0002

Rourke, L., & Anderson, T. (2002). Exploring social communication in asynchronous, text-based computer conferencing. *Journal of Interactive Learning Research*, *13*(3), 259–275. https://www.learntechlib.org/primary/p/15133/

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (2001). Assessing social presence in asynchronous text-based computer conferencing. *Journal of Distance Education*, *14*(2), 50–71. https://core.ac.uk/download/pdf/58774853.pdf

Rovai, A. P. (2002). Building sense of community at a distance. *The International Review of Research in Open and Distributed Learning*, *3*(1). https://doi.org/10.19173/irrodl.v3i1.79

Rovai, A. P. (2018). Building sense of community at a distance. *Distances et médiations des savoirs*, (23). https://doi.org/10.4000/dms.2685

Rudd, M., & Honkiss, L. (2020). *Analysing the correlation between English proficiency and academic performance among thai university students* (EJ1237431). ERIC. https://eric.ed.gov/?id=EJ1237431

Rutberg, S., & Bouikidis, C. (2018). Focusing on the fundamentals: a simplistic differentiation between qualitative and quantitative research. *Nephrology Nursing Journal*, *45*(2), 209–212.

Salim Muljana, P., & Luo, T. (2019). Factors contributing to student retention in online learning and recommended strategies for improvement: A systematic literature review. *Journal of Information Technology Education: Research*, *18*, 019–057. https://doi.org/10.28945/4182

Salkind, N. (2010). *Encyclopedia of research design: volume 1*. SAGE Publications. https://doi.org/10.4135/9781412961288

Sallnäs, E.-L. (2005). Effects of communication mode on social presence, virtual presence, and performance in collaborative virtual environments. *Presence: Teleoperators and Virtual Environments*, *14*, 434–449. https://doi.org/10.1162/105474605774785253

Scheffer, D., & Heckhausen, H. (2009). Trait theories of motivation. In Heckhausten, J. (Ed.), *Motivation and action* (pp. 42–68). Cambridge University Press. https://doi.org/10.1017/cbo9780511499821.004

Sealy, R., & Singh, V. (2006). Role models, work identity and senior women's career progression - why are role models important? *Academy of Management Proceedings*, *2006*(1), E1–E6. https://doi.org/10.5465/ambpp.2006.22898277

Seery, K., Barreda, A. A., & Hein, S. G. (2021). Retention strategies for online students: a systematic literature review. *Journal of Global Education and Research*, *5*(1), 72–84. https://doi.org/10.5038/2577-509X.5.1.1105

Seimens, G. (2005). Connectivism: a learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, *2*, 1–9. https://jotamac.typepad.com/jotamacs_weblog/files/Connectivism.pdf

Shaikh, U., & Asif, Z. (2022). Persistence and dropout in higher online education: Review and categorization of factors. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.902070

Shan, G., Zhang, H., & Jiang, T. (2020). Correlation coefficients for a study with repeated measures. *Computational and Mathematical Methods in Medicine*, *2020*, 7398324. https://doi.org/10.1155/2020/7398324

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*(3-4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Shea, P., & Bidjerano, T. (2010). Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments. *Computers & Education*, 55(4), 1721–1731. https://doi.org/10.1016/j.compedu.2010.07.017

Shea, P., & Bidjerano, T. (2012). Learning presence as a moderator in the community of inquiry model. *Computers & Education*, *59*(2), 316–326. https://doi.org/10.1016/j.compedu.2012.01.011

Shea, P., Sau Li, C., & Pickett, A. (2006). A study of teaching presence and student sense of learning community in fully online and web-enhanced college courses. *The Internet and Higher Education*, *9*(3), 175–190. https://doi.org/10.1016/j.iheduc.2006.06.005

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications*. Wiley London.

Shye, S. (2021). Organizational quality: A systemic functioning theory. In Solomon, E. (Ed.), *Facet theory in organizational research* (pp. 15–32). Routledge. https://doi.org/10.4324/9781003172154-2

Simpson, O. (2003). *Student retention in online, open and distance learning*. Routledge. http://dx.doi.org/10.4324/9780203416563-4

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online Learning (1988-2018). *American*

Journal of Distance Education, *33*(4), 289–306. https://doi.org/10.1080/08923647.2019.1663082

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, *6*(6), 603–616. https://doi.org/10.1162/pres.1997.6.6.603

Sledgianowski, D., & Kulviwat, S. (2009). Using social network sites: The effects of playfulness, critical mass and trust in a hedonic context. *Journal of Computer Information Systems*, *49*(4), 74–83. https://doi.org/10.1080/08874417.2009.11645342

Sofroniou, A., Premnath, B., & Poutos, K. (2020). Capturing student satisfaction: a case study on the national student survey results to identify the needs of students in STEM related courses for a better learning experience. *Education Science*, *10*(12), 378. https://doi.org/10.3390/educsci10120378

Sokal, A. (2010). *Beyond the hoax: Science, philosophy and culture* (Illustrated ed.). Oxford University Press.

Stankovska, G., Dimitrovski, D., Ibraimi, Z., & Memedi, I. (2021). *Online learning, social presence and satisfaction among university students during the covid-19 pandemic* (ED613967). ERIC. https://eric.ed.gov/?id=ED613967

Steuer, J. (1992). Defining virtual reality: dimensions determining telepresence. *Journal of Communication*, *42*(4), 73–93. https://doi.org/10.1111/j.1460-2466.1992.tb00812.x

Stoytcheva, M. (2021). Developing a sense of belonging in a collaborative distance learning course: Breaking isolation in online learning. *AIP Conference Proceedings 2333, 050010*. https://doi.org/10.1063/5.0043330

Syahira, S., Tarmizi, A., Mutalib, S., Hamimah, N., Hamid, A., & Rahman, S. A. (2019). A review on student attrition in higher education using big data analytics and data mining techniques. *I.J. Modern Education and Computer Science*, *8*, 1–4. https://doi.org/10.5815/ijmecs.2019.08.01

Tabachnick, B., & Fidell, L. (2007). *Using Multivariate Statistics* (7th ed.). Pearson.

Takács, R., Kárász, J. T., Takács, S., Horváth, Z., & Oláh, A. (2022). Successful Steps in Higher Education to Stop Computer Science Students from Attrition. In Interchange (Vol. 53, Issues 3–4, pp. 637–652). Springer Science and Business Media LLC. https://doi.org/10.1007/s10780-022-09476-2

Talley, K., & Martinez Ortiz, A. (2017). Women's interest development and motivations to persist as college students in STEM: A mixed methods analysis of views and voices from a Hispanic-serving institution. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0059-2

Thomas Theorem. (2011b). In D. Chandler & R. Munday (Eds.), *A dictionary of media and communication*. Oxford University Press. https://doi.org/10.1093/acref/9780199568758.001.0001

Thomas, W. I., & Thomas, D. S. (1970, 1928). *The child in America, behavior problems & programs* (2nd ed.). Hempbri.

Tight, M. (2020). Student retention and engagement in higher education. *Journal of Further and Higher Education*, *44*(5), 689–704. https://doi.org/10.1080/0309877X.2019.1576860

Tolu, A., & Evans, L. (2012). From distance education to communities of inquiry. In Akyol, Z. & Garrison, D. (Eds.), *Educational communities of inquiry: theoretical framework, research and practice* (pp. 45–65). IGI Global. https://doi.org/10.4018/978-1-4666-2110-7.ch004

Trapani, J., & Hale, K. (2019). *Higher Education in Science and Engineering. Science & Engineering Indicators 2020* (NSB-2019-7). National Science Board of the National Science Foundation. https://files.eric.ed.gov/fulltext/ED599398.pdf

Tu, C.-H., & McIsaac, M. (2002). The relationship of social presence and interaction in online classes. *American Journal of Distance Education*, *16*(3), 131–150. https://doi.org/10.1207/s15389286ajde1603_2

Tung, F.-W., & Deng, Y.-S. (2007). Increasing social presence of social actors in e-learning environments: Effects of dynamic and static emoticons on children. *Displays*, *28*(4-5), 174–180. https://doi.org/10.1016/j.displa.2007.06.005

Turkle, S. (2005). *The second self: Computers and the human spirit* (Twentieth Anniversary ed.). The MIT Press.

Turkle, S. (2012). *Alone together: Why we expect more from technology and less from each other* (1st ed.). Basic Books.

Turkle, S. (2015, October 2). *How to teach in an age of distraction*. The Chronicle of Higher Education. https://www.chronicle.com/article/how-to-teach-in-an-age-of-distraction/

Turkle, S. (2016). *Reclaiming conversation: The power of talk in a digital age* (Reprint ed.). Penguin Books.

Utecht, J., & Keller, D. (2019). *Becoming relevant again: Applying connectivism learning theory to today's classrooms* (EJ1219672). ERIC. https://eric.ed.gov/?id=EJ1219672

Voinohovska, V., Tsankov, S., & Goranova, E. (2019). *Development of the students' computational thinking skills with project-based learning in Scratch programming environment* (INTED2019 Proceedings). 13th International Technology, Education and Development Conference. https://doi.org/10.21125/inted.2019.1309

Wall, K. (2019). *Persistence and representation of women in STEM programs* (Catalogue no. 75-006-X). Insights on Canadian Society. https://files.eric.ed.gov/fulltext/ED594933.pdf

Walter, J. B. (1986). Computer-mediated communication: Impersonal, interpersonal, and hyperpersonal interaction. *Communication Research, 23*, 3–43. https://doi.org/10.1177/009365096023001001

Walther, J. (1996). Interpersonal effects in computer-mediated interaction a relational perspective. *Communication Research, 19*, 52–90. https://doi.org/10.1177/009365092019001003

Wanzer, D., McKlin, T., Freeman, J., Magerko, B., & Lee, T. (2020). Promoting intentions to persist in computing: An examination of six years of the EarSketch program. *Computer Science Education*, *30*(4), 394–419. https://doi.org/10.1080/08993408.2020.1714313

Warren, A. (2018). Exploring experienced teachers' constructions of culturally and linguistically diverse students in an online class. *International Journal of Multicultural Education*, *20*(2), 58–80. https://files.eric.ed.gov/fulltext/EJ1184942.pdf

Whitcomb, K. M., Cwik, S., & Singh, C. (2021). Not all disadvantages are equal: Racial/ethnic minority students have largest disadvantage among demographic groups in both STEM and non-STEM GPA. *AERA Open*, *7*, 233285842110598.https://doi.org/10.1177/23328584211059823

Whitcomb, K. M., & Singh, C. (2021). Underrepresented minority students receive lower grades and have higher rates of attrition across STEM disciplines: A sign of inequity? *International Journal of Science Education*, *43*(7), 1054–1089. https://doi.org/10.1080/09500693.2021.1900623

White, J., & Massiha, G. H. (2016). The retention of women in science, technology, engineering, and mathematics: a framework for persistence. *International Journal of Evaluation and Research in Education (IJERE)*, *5*(1), 1–8. https://files.eric.ed.gov/fulltext/EJ1094603.pdf

Whiteside, A. L., Dikkers, A. G., & Swan, K. (2017). *Social presence in online learning* (1st ed.). Stylus Publishing.

Wiener, M., & Mehrabian, A. (1968). *Language within language: Immediacy, a channel in verbal communication*. Appleton-Century-Crofts.

Williams, E. A., Duray, R., & Reddy, V. (2006). Teamwork orientation, group cohesiveness, and student learning: A study of the use of teams in online distance education. *Journal of Management Education*, *30*(4), 592–616. https://doi.org/10.1177/1052562905276740

Wladis, C., Conway, K. M., & Hachey, A. C. (2015). The online STEM classroom—who succeeds? An exploration of the impact of ethnicity, gender, and non-traditional student characteristics in the community college context. *Community College Review*, *43*(2), 142–164. https://doi.org/10.1177/0091552115571729

Wood, S. L. (2010). *Technology for teaching and learning: Moodle as a tool for higher education* (EJ938565). ERIC. https://eric.ed.gov/?id=EJ938565

Wright, H. M. (2019, March). *Expanding the Pipeline: CERP Data Buddies Survey Finishes Strong with More Insights About Students' Experiences*. Computing Research Association. Retrieved August 28, 2022, from https://cra.org/crn/2019/03/expanding-the-pipeline-cerp-data-buddies-survey-finishes-strong-with-more-insights-about-students-experiences/

Wright, H., & Tamer, N. (2019). Can sending first and second year computing students to technical conferences help retention? *Proceedings of the 50th ACM Technical Symposium on Computer Science Education (SIGCSE '19)*, 56–62. https://doi.org/10.1145/ 3287324.3287349

Xu, D., & Jaggars, S. (2011). The effectiveness of distance education across Virginia's community colleges: Evidence from introductory college-level Math and English courses. *Educational Evaluation and Policy Analysis*, *33*(3), 360–377. https://doi.org/10.3102/0162373711413814

Yang, D., Lavonen, J. M., & Niemi, H. (2018). Online learning engagement: critical factors and research evidence from literature. *Themes in eLearning*, *11*(1), 1–18. http://earthlab.uoi.gr/tel

Yu, Q. (2022). Factors influencing online learning satisfaction. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.852360

Zahedi, L., Ebrahiminejad, H., Ross, M., Ohland, M., & Lunn, S. (2021). Multi-institution study of student demographics and stickiness of computing majors in the USA. *Collaborative Network for Engineering and Computing Diversity (CoNECD)*.

Zahedi, L., Lunn, S., Pouyanfar, S., Ross, M., & Ohland, M. (2020). Leveraging machine learning techniques to analyze computing persistence in undergraduate programs. *2020 ASEE Virtual Annual Conference Content Access*, 15. https://doi.org/10.18260/1-2--34921

Zhan, Z., & Mei, H. (2013). Academic self-concept and social presence in face-to-face and online learning: Perceptions and effects on students' learning achievement and satisfaction across environments. *Computing Education*, *69*, 131–138. https://doi.org/10.1016/j.compedu.2013.07.002

Zhao, S., & Elesh, D. (2008). Copresence as 'being with'. *Information, Communication & Society*, *11*(4), 565–583. https://doi.org/10.1080/13691180801998995

Zhonggen, Y., Ying, Z., Zhichun, Y., & Wentao, C. (2018). Student satisfaction, learning outcomes, and cognitive loads with a mobile learning platform. *Computer Assisted Language Learning*, *32*(4), 323–341. https://doi.org/10.1080/09588221.2018.1517093

Zumbo, B. D., & Rupp, A. A. (2009). Responsible modeling of measurement data for appropriate inferences: important advances in reliability and validity theory. In D. Kaplan (Ed.), *The SAGE handbook of quantitative methodology for the social sciences* (pp. 73–92). SAGE Publications.

Appendix A

Ethics Review Committee Approval Letter

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2023/02/08

Ref: **2023/02/08/35135549/11/AM**
Name: JD Reichard
Student No.:35135549

Dear JD Reichard

Decision: Ethics Approval from 2023/02/08 to 2028/02/08

Researcher(s): Name: JD Reichard
E-mail address: 35135549@mylife.unisa.ac.za
Telephone: +1 330 651 0225

Supervisor(s): Name: Prof Mishack T Gumbo
E-mail address: gumbomt@unisa.ac.za
Telephone: 012 429 3339

Title of research:

Computer Science Students' Perceptions of Social Presence in Online Degree Programmes: A Quantitative Ex-Post-Facto Correlational Study

Qualification: PhD Computer Science Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2023/02/08 to 2028/02/08.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2023/02/08 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

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Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
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3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2028/02/08**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2023/02/08/35135549/11/AM** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof Mpine Makoe
ACTING EXECUTIVE DEAN
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Appendix B

CERP Survey Instrument

Due to its large file size, the survey is not embedded as an appendix, but it can be accessed online at: https://cra.org/cerp/data-buddies/#measures

Appendix C

Proof of Language Editing

NANETTE J LöTTER

PROFESSIONAL EDITING AND TRANSLATING

TO WHOM IT MAY CONCERN

This is to certify that the PhD thesis titled: *Computer Science students' perceptions of social presence related to student retention in online degree programmes: A quantitative ex post facto correlational study* by Joshua D. Reichard, Student Number: 35135549, was electronically edited during August and September 2023.

All language and technical errors were corrected, and editorial comments and recommendations were made. It remains however the responsibility of the author ensure that the changes and amendments are accepted.

9 January 2024

Nanette J Lötter
BA HED MA (Linguistics and Translation) APEd, APTrans
Accredited Professional Editor and Translator (South African Translators' Institute)
Cell No: 082 2024 244
Email: nanette.lotter@gmail.com

Appendix D

Turnitin Report

Direct quotes and references are excluded.

Turnitin Originality Report

Processed on: 09-Nov-2023 15:11 SAST
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Final Dissertation By Joshua Reichard

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