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A Longitudinal Analysis of Academic Self-Concept Among Preclinical Medical Students

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

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Master of Science, Virginia Commonwealth University, 2013

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Medical school plays a pivotal role in the training of future physicians. Academic Self-Concept (ASC) represents a person's beliefs about their academic ability, and it has been documented across educational contexts as an important factor in relation to academic performance. Despite decades of research into the relationship between ASC and academic performance, this relationship remains underexplored in medical education. The purpose of this study was to examine the ASC of preclinical medical students using longitudinal data to explore both the relationship between ASC and performance and ASC throughout the preclinical phase of medical school. Survey data from three cohorts of preclinical medical students, for a total sample of 495 students, was analyzed. Bivariate correlation and simple linear regression analysis was used to explore the relationship between preadmissions performance and ASC during matriculation to medical school. There was a statistically significant positive relationship between preadmissions performance and ASC, but a low correlation coefficient suggested the relationship was not a practically significant one. Ordinal regression was used to explore the relationship between ASC and academic performance, as measured by rank quartile. In an analysis of factors influencing rank quartile at the end of the first year, ASC was a statistically significant predictor of subsequent performance, though prior academic performance was the strongest predictor of subsequent performance. Ordinal regression was also used to determine the impact of ASC at the end of the first year on academic performance at the end of the second year. The results of this analysis also suggested that ASC plays a statistically significant role in performance, but prior performance was again the strongest predictor of subsequent performance. Repeated measures ANOVA was conducted to explore changes in ASC over time. There was a significant decline in ASC between matriculation and the end of the first and second years, but there was not a significant difference in ASC between the end of the first and the end of the second year of medical school. The results of these analyses provide support for the relationship between ASC and academic performance among preclinical medical students. Evidence of this relationship, as well as the decline in ASC over time, provide insight into the experiences of medical students that may be used to help improve those experiences, as well as academic processes and outcomes.

Chapter 1 Introduction

The goal of medical education is to produce a physician workforce that can meet the needs of the patients and populations they serve (Holmboe et al., 2017). Medical school, also referred to as undergraduate medical education, is the first major step on the path to practicing medicine after a learner completes a bachelor's degree program. The training students receive during this time prepares them for residency, also known as graduate medical education, and their future careers. As patients, we often see physicians when they are fully trained and certified to practice medicine. We expect our doctors to have the relevant knowledge and skills to provide competent care, and while every physician has individual characteristics that might inform the care they provide, they all complete their training in medical school. The education an individual receives during medical school is integral in the process of their development as a future physician. This educational journey does not pertain solely to their acquisition of content knowledge and skills as they progress through key stages in their medical education, but also to their experiences in and outside of the classroom and internal factors such as beliefs about their own learning.

Academic self-concept (ASC) represents the beliefs a student holds about their academic ability (Marsh, 1990). An extensive body of research on ASC in primary and secondary educational contexts has established a foundation to understand the construct. Research in post-secondary education has provided further insight into ASC for adult learners, but ASC is an underexplored construct in medical education.

Academic performance is one of the most common factors examined in relation to ASC (Arens et al., 2021). The relationship between the two is well-established across educational contexts, from K-12 to higher education, but less is known about ASC in medical education.

Studies in the 1970s focused on two models of this relationship: the skills development model, where academic performance impacts ASC, and the self-enhancement model, where ASC impacts academic performance (Calsyn & Kenny, 1977). The reciprocal effects model (REM) subsequently emerged as the dominant model, which posits that ASC impacts academic performance, which impacts subsequent ASC (Marsh et al., 2005). This model is currently applied to most studies focused on the relationship between ASC and academic performance.

Selection into medical school and into residency are highly competitive processes. Medical school itself can be competitive, with many high-performing students, who may have been among the top performers at their undergraduate learning institutions, surrounded by other high-performing students. The first year of medical school is an adjustment period for students, and the learning environment can impact both ASC and performance (Zhou et al., 2015). Grading schemes and curriculum structures may affect student experiences, and understanding these relationships is important to know how best to address student needs and positively impact performance. If the goal of medical education is to produce a workforce of physicians able to meet the needs of their patients and the populations they serve (Holmboe et al., 2017), medical school plays an important role in the development and training of future physicians. Academic performance is the primary metric used to measure the success of a student. Marsh and Craven (2006) asserted that it is not enough to enhance the skills of an individual; a positive self-concept is necessary to maximize performance.

The next section will provide a brief overview of ASC as a construct, as well as an introduction to related constructs. Byrne (1984) asserted that an understanding of ASC is a requisite of research about it.

Academic Self-Concept (ASC)

ASC a facet of self-concept, which broadly represents the views an individual holds about themselves (Shavelson et al., 1976). ASC is a prolific construct of interest in educational research, with decades of research in primary, secondary, and post-secondary educational settings providing some foundational understanding of the internal structure of ASC, how an individual develops ASC, and relationships with other factors; specifically, the relationship between ASC and academic performance. ASC is accepted to be multidimensional and hierarchical (Shavelson et al., 1976), though in a methodological review of the structure of ASC, Arens et al. (2021) reviewed five models of ASC. All five models are multidimensional, but not all are hierarchical. ASC develops through three major comparative processes that students use: social, dimensional, and temporal (Möller et al., 2020). Social comparisons are those made against peers (Gerber et al., 2018), temporal comparisons are those students make against previous performance (Wilson & Ross, 2000), and dimensional comparisons are those made against performance in other domains, such as comparing performance with math with performance in verbal reasoning (Möller & Marsh, 2013). These processes have been demonstrated in primary and secondary student populations (Marsh & Hau, 2004; Möller et al., 2011; Wolff et al., 2018) as well as among learners in college and university settings (Wilson & Ross, 2000; Wolff et al., 2018), but they have not been studied in medical education.

There are several constructs that are similar, and related, to ASC, which are briefly explored in the following sections to further highlight the unique features of ASC. As it is important to understand what ASC is, it is also important to understand what it is not.

Constructs related to Academic Self-Concept

Self-efficacy

Self-concept as a global construct differs from self-efficacy. Both constructs are underscored by self-appraisal, but they differ in several meaningful ways. Where self-concept focuses on an individual's view of their self or abilities in a specific domain, self-efficacy more specifically focuses on an individual's belief that they can complete a task or achieve an objective (Bong & Skaalvik, 2003). Bandura (1997) proposed four major factors that inform self-efficacy: enactive mastery experience, vicarious experience, verbal persuasion, and physiological reactions. Enactive mastery experience includes prior experiences with a task or activity. Vicarious experience includes an appraisal based on the abilities of others to perform a task. Verbal persuasion is informed by persuasive communication and feedback from others. Physiological reactions include heightened physiological arousal, such as sweating or mood changes, that impact an individual's self-appraisal around a given task. While theorists draw clear theoretical and conceptual distinctions between ASC and self-efficacy, their differences become more subtle, and the constructs are more difficult to differentiate within the specific context of education (Bong & Skaalvik, 2003). Ferla et al. (2009) conducted a study to determine whether ASC and academic self-efficacy represented distinct constructs. They found that even when measured within the same domain, such as math, the constructs were conceptually and empirically different.

Imposter syndrome

More recent studies into medical practitioners have highlighted the prevalence of imposter syndrome, which is characterized as someone who does not experience a sense of success despite high achievement (LaDonna et al., 2018). There is limited research into the connection between ASC, self-efficacy, and imposter syndrome, but the existing research suggests a relationship between these three constructs; in a study of university students, Cokley et al. (2015) demonstrated a negative relationship between imposter syndrome and ASC, where individuals with higher imposter syndrome scores had less academic confidence. In a study of Belgian employees across various work sectors, Vergauwe et al. (2015) found that self-efficacy was the strongest characteristic associated with imposter syndrome.

Statement of the problem

While the relationship between ASC and performance is well-established in the K-12 literature, there is a significant gap in our understanding of this relationship during medical school. Further, most research on ASC in medical education uses cross-sectional analyses to explore one-way relationships, such as studies where ASC is studied only as an outcome (Abdalla et al., 2019; Litmanen et al., 2014), and these studies do not focus directly on the relationship between ASC and academic performance. Of the two studies that explored ASC and academic performance among medical students, both used longitudinal analysis, but they focused only on the first year of medical school (Jackman et al., 2011; Zhou et al., 2015). The conclusions that can be drawn from this small body of literature are limited.

The preclinical phase of the curriculum may vary in length across institutions but refers to the education students receive prior to clinical training. This phase is characterized primarily by didactic learning with a focus on basic sciences (Gaur et al., 2020) and which generally occurs in the first two years of medical school. In recent years, small group sessions, team-based learning (TBL), problem-based learning (PBL), and flipped lectures have been increasingly utilized to transition from didactic, lecture-based learning (LBL) and to promote student-centered learning (Gaur et al., 2020). Grading in this phase also varies across institutions, but many medical schools have adopted a pass/fail approach to curriculum in the preclinical curriculum (Murphy, 2020). Anecdotally, medical schools use academic or class rank as a metric of performance, but it is unclear how many schools use this approach and how it is reported or whether it serves as an internal metric only. Medical schools have little to no control over individual attributes of a student, but they can control aspects of the learning environment (Dyrbye et al., 2011), including measurement of performance. A longitudinal analysis of the relationship between ASC and academic performance during the preclinical phase would provide schools a deeper insight into student needs and experiences beyond the first year of medical school. Study findings may also help to identify specific points in the curriculum where ASC or performance may change, which would highlight opportunities for interventions to support those students experiencing learning challenges.

Brief Review of ASC Literature in Medical Education

The existing research focused on ASC of medical students is relatively small when compared with studies in elementary, secondary, and higher education populations. Within the medical education literature, ASC is explored in relation to academic performance or achievement (Jackman et al., 2011; Zhou et al., 2015), the learning environment (Abdalla et al., 2019; Litmanen et al., 2014) and well-being (Yamada et al., 2014). This brief overview of the literature addresses five studies specific to medical students. This includes a review of the definition and operationalization of ASC across studies, methodologies used, measurement of ASC, and the relationships explored.

Research questions

The research questions specific to the relationships between ASC and other factors varied across studies. Two studies (Jackman et al., 2011; Zhou et al., 2015) explored the relationship between ASC and academic performance. Jackman et al. (2011) investigated whether ASC declined after first-year medical students received their first written assessment. The authors did not find a significant change in ASC before the assessment and after. Zhou et al. (2015) also studied ASC and academic performance among first-year medical students. They collected ASC from students on entry to medical school and again in their first year. While they found that ASC was related to performance, the authors stated that their overall model explained only 25% of variation in performance. Litmanen et al. (2014) and Abdalla et al. (2019) studied ASC in relation to the learning environment. Abdalla et al. (2019) studied relationships between ASC and attitudes toward PBL and found that positive perceptions of the learning environment positively impacted ASC. Litmanen at al. (2014) researched the relationship between ASC, perceptions of the learning environment, and experiences with well-being. They found that students in the PBL curriculum reported higher ASC during their preclinical phase, but differences were not significant in the clinical phase. Yamada et al. (2014) also studied ASC and well-being. They found student distress and well-being were associated with ASC, where students with poor ASC had poorer well-being outcomes and reported lower social support from friends.

Methods used

All five studies used quantitative data collection and analysis methods. Surveys and questionnaires were used for data collection across all studies. Data analyses varied by research question and study. Three studies conducted cross-sectional analyses (Litmanen et al., 2014; Yamada et al., 2014; Abdalla et al., 2019), and two studies analyzed longitudinal data (Jackman et al., 2011; Zhou et al., 2015). Litmanen et al. (2014) studied medical students across three institutions and across two phases of their medical education. Abdalla et al. (2019) conducted a cross-sectional analysis of phase one medical students, which included students in their first and second years of medical school. In contrast, Yamada et al. (2014) invited students from all years in a six-year program to participate in their study and analyzed them by phase (preclinical and clinical). Both studies that used a longitudinal design analyzed students in their first year of medical school (Jackman et al., 2011; Zhou et al., 2015). Only one study incorporated qualitative methods (Jackman et al., 2011). This study was a multiphase study of first-year medical students in Australia, Jackman et al. (2011) used survey data collection methods in the first phase of their study and conducted semi-structured focus groups in the second phase of their study. The authors used thematic analysis to review data. The results of the qualitative phase of their study supported that students' ASC is informed by comparison with peers. The studies noted here used varying methodologies, primarily quantitative, to address the different research questions. The measurement of ASC was also variable, with a more in-depth review of these approaches below.

Measurement

Measurement of ASC was inconsistent across studies. No two studies used the same instrument to assess students' ASC. In their study of phase one medical students, Abdalla et al. (2019) used a modified 8-item version of the Academic Self Concept scale (Liu et al., 2005) to understand the relationship between academic self-concept and perceptions of problem-based learning (PBL). Yamada et al. (2014) used a subscale of the Dundee Ready Education Environment Measure (DREEM) to capture academic self-concept. The subscale used wass specific to academic self-concept and contained 8 items with a 5-point Likert agreement scale (0=strongly disagree and 4=strongly agree). Scores ranged from 0 to 32, where higher scores indicated stronger self-concept. Yamada et al. identified the lowest 30% of the score distribution as "poor" academic self-concept, with all other students considered as "not poor." Zhou et al. (2015) used an academic self-concept measure from the Cooperative Institutional Research Program's (CIRP) Your First College Year Survey (YFCY). ASC was measured through 5 items around academic ability, which included specific items measuring academic ability, creativity, mathematical ability, drive to achieve, and intellectual self-confidence. The items used a 5-point Likert scale where participants (first-year medical students) were asked to indicate self-perception of their abilities compared with their peer group, where 1 = "Lowest 10%", 2= "Below average," 3 = "average," 4 = "above average," and 5= "top 10%." Likert type scales are not the only method used to measure Academic Self-Concept. Single items were used to measure academic self-concept in multiple studies (Jackman et al., 2011; Litmanen et al., 2010). Jackman et al. (2011) used a combination of a Likert type scale and a single-item social comparison question. The single item measure asked medical students to indicate how much better or worse they were academically compared with their peers, where a 1 indicated they were much worse and a 5 indicated they were much better. Jackman et al. also used the Academic Self-Description Questionnaire II (ASDQII) (Marsh, 1992) to measure ASC. The ASDQII uses an 8-point Likert type scale to measure ASC across multiple subjects. Jackman et al. (2011) modified the items to remove specific school subjects and replaced them with "most academic subjects."

In a study exploring the relationships between ASC, well-being, and the learning environment, academic self-concept was measured through a single item comparing performance of an individual against that of their class (Litmanen et al., 2014). Participants were given three response options and asked to indicate whether they believed their grade to be worse than, about the same as, or better than the average of their class (Litmanen et al., 2019). A lack of consistency in measurement of ASC across studies limits the generalizability of the findings. Not all authors provided validity evidence for their measures, further limiting the inference from findings. Single-item measures in particular are difficult because while there are methods to establish validity, there is no way to determine internal consistency, which presents major challenges for establishing reliability. The measurement of ASC is relevant to the present study because it helps to establish what is known about the construct in the context of medical education.

Operationalization of ASC

Definitions of ASC varied across studies in medical education, but there were common elements, such as items or measures specific to peer comparison. Four of the five studies addressed or defined ASC as a specific construct, while one study (Yamada et al., 2014), used academic self-perception as a proxy for performance. Zhou et al. (2015) mentioned ASC in combination with self-efficacy but did not explicitly define ASC. Other studies (Jackman et al., 2011; Litmanen et al., 2014; Abdalla et al., 2019) provided a broad definition of ASC as the beliefs an individual holds about their academic abilities. Two studies operationalize ASC as dependent on social comparison (Litmanen et al., 2014; Zhou et al., 2015).

A review of this small body of literature highlights several gaps and areas in need of further exploration. Inconsistencies in the operationalization of ASC lead to differences in measurement across studies. No two studies use the same measure, so no findings have been reproduced across studies. Most studies used cross-sectional methods to explore academic self-concept. Cross-sectional analyses enable exploration of academic self-concept within the skills development model and self-enhancement model, while reciprocal effects are best tested through longitudinal methods (Valentine et al., 2004). Despite mixed results and limited generalizability, these studies provide a foundation for contextualizing ASC in medical education and inform the current study. The relationship between ASC and academic performance has been explored among first-year medical students, but there is no analysis of this relationship beyond the first year. Litmanen et al. (2014) demonstrated differences in ASC between preclinical and clinical phase students, though these findings were from a cross-sectional analysis and not specific to academic performance. A longitudinal analysis of ASC and academic performance during medical school would provide a deeper understanding of this relationship and would enable medical schools to more effectively support student learning and their academic experience. Between academic years 1996-97 and 2015-16, the Association of American Medical Colleges (AAMC) reported a stable average attrition rate of 3.2% among MD students (not including students in dual-degree programs), with 1.3% reported for academic reasons, and 1.8% reported for non-academic reasons (AAMC, 2020). It can be difficult for schools to identify learners who are struggling or are at risk of academic failure in the preclinical phase (Ahmady et al., 2019), and so having more information about the potential role of ASC and its relationship with academic performance may provide insight for educators and medical school leadership. The purpose of this study is to better understand students' ASC during the preclinical phase of the curriculum, including the relationship between ASC and academic performance. This chapter introduces the role of ASC in medical student development and research needed to further the understanding of this relationship to improve medical school education. The chapter includes a brief literature review, the research questions for this study, and an overview of the methodology. Chapter two provides a more detailed review of the literature specific to ASC in medical school. This study addresses the following research questions:

Research questions

The research questions include:

RQ1: Does pre-admissions performance relate to ASC at matriculation?

RQ2: What factors influence academic performance during the preclinical phase?

RQ3: Does ASC change over time throughout the preclinical phase of medical school?

Methodology

The study sample included three cohorts of medical students at a large, Mid-Atlantic medical school. Survey data was collected during orientation in the first week of medical school, at the end of the first year, and the end of the second year. ASC was measured with the Academic Self-Concept Scale (Liu et al., 2005). The original ASC scale included 19 items and two subscales: effort and confidence. The 9-item confidence subscale was used in the present study. The items use a 4-point Likert-type scale, where 1=strongly disagree and 4=strongly agree. Scores from the Medical College Admissions Test (MCAT) were used as a metric for academic performance prior to admissions. Academic performance during medical school was measured using academic rank quartile.

Bivariate correlation analysis and simple linear regression were used to address the first research question. A bicorrelation analysis was used to indicate whether there was any relationship between pre-admissions performance and ASC at matriculation. A linear regression analysis was conducted to determine the amount of variance in ASC explained by prior performance.

To address the second research question, ordinal regression was conducted to analyze the relationship between ASC and academic performance across the three cohorts. The first analysis looked at ASC at matriculation and its impact on subsequent academic performance at the end of M1 year, and the second analysis looked at ASC at the end of M1 year and its impact on academic performance at the end of M2 year.

Repeated measures ANOVA was used to address the third research question. The purpose of this analysis was to determine whether there were mean differences in ASC across different timepoints.

Definition of terms

AAMC: Association of American Medical Colleges. The accrediting body for medical schools in the US and Canada.

Clinical phase: The period of medical education prior to graduation and residency. This phase of medical school is characterized by clinical exposure to patients through clerkships and other clinical rotations where students practice medicine with supervision.

LBL: Lecture-based learning. A traditional learning approach that primarily focuses on delivery of content through a lecture.

M1: A term for a medical student in their first year of undergraduate medical education

M2: A term for a medical student in their second year of undergraduate medical education

MCAT: Medical College Admissions Test. A standardized exam used as a metric in most medical school admissions processes.

PBL: Problem-based learning. A learning approach that primarily focuses on group learning where students work to solve open-ended problems.

Preclinical phase: The period of medical education prior to clinical training. This phase of medical school often spans two years but is variable across schools. Preclinical curricula largely focus on classroom instruction as opposed to clinical interactions with patients.

REM: Reciprocal effects model. This is the dominant model to explain the relationship between ASC and academic performance in the K-12 education literature. This model suggests that prior ASC informs subsequent performance, which influences subsequent ASC.

TBL: Team-based learning. A learning approach that combines individual and team work with immediate feedback to apply concepts.

Chapter 2 Literature Review

The purpose of this study is to better understand medical students' ASC; specifically, the relationship between ASC and academic performance. This chapter includes a review of the ASC literature, including a description of the construct, what is known about the development of ASC, and associated factors. This section also explores the relationship between ASC and academic performance. The second part of the chapter highlights literature on ASC and medical education, which includes a review of how medical education is structured, how performance is broadly assessed in medical school, and a presentation and analysis of studies focused specifically on ASC in the context of medical education.

ASC

Structure and definition

Self-concept (SC) is defined as the views an individual holds about themself and is broadly informed by an individual's experiences with and perceptions of their environment (Shavelson et al., 1976). ASC is a facet of self-concept specific to academic abilities. Byrne (1984) proposed that research into ASC requires an understanding of the construct. This section explores both the internal structure of ASC and provides an introduction to associated factors. ASC is recognized as both a hierarchical and multidimensional construct (Shavelson et al., 1976). The multidimensionality of the construct indicates ASC comprises distinct, domain-specific areas, while the hierarchy refers to different levels of generality of those areas (Arens et al, 2021). In a methodological review of ASC's structure, Arens et al. (2021) included five models. These models represent a development from Shavelson et al.'s (1976) work to more recent conceptual approaches to measuring and understanding ASC.

In the model of SC posited by Shavelson et al. (1976), SC is at the top of a hierarchy that is further divided into academic and non-academic self-concepts (Marsh et al., 1988). This is a higher-order factor model where subject-specific domains represent first-order factors that fall under a general factor that represents ASC. In this model, subjects like math and verbal reasoning are considered first-order factors, and ASC is the higher-order factor they load onto. This model could not be validated through research (Marsh, 1990), which led to the development of the Marsh/Shavelson model of ASC. In this model, there are two higher-order factors (Math/Academic and Verbal/Academic), as opposed to a single higher-order factor (ASC) as described in Shavelson et al.'s original model (Marsh, 1990). Marsh (1990) posited that this model was sufficient for testing primary academic subjects but could not demonstrate correlations between other subjects. Developments in structural equation modeling led to the nested Marsh/Shavelson model (Brunner et al., 2010). In this model, subject-specific domains are represented as first-order factors that operate independently of general academic self-concept, which is represented as a second-order factor. A fourth model of ASC uses a bifactor-Exploratory Structural Equation Modeling (ESEM). Bifactor-ESEM allows for cross-loading across factors, something typically restricted in confirmatory factor analysis, which is used in structural equation modeling to measure latent variables. Arens et al. (2017) applied this model to understand what they described as the joint factor model that includes both academic and non-academic domains of self-concept. Finally, there is a first-order factor model where all ASC factors are hierarchically on the same level (Arens et al., 2021). This is the only model that is multidimensional but not hierarchical, which goes against the original assumptions Shavelson (1976) made about ASC.

The higher-order factor model, Marsh/Shavelson model, Nested Marsh/Shavelson model, Bifactor-ESEM, and the first order model represent different theoretical approaches used to measure ASC and their application in academic settings. Uniform across these models is the assumption of multidimensionality. The measure of ASC used in the current study was developed as a first-order factor model (Liu et al., 2005), so it is multidimensional but not hierarchical.

Arens et al. (2021) distinguished between two primary areas of research inquiry into ASC. The first is within-network analysis, which focuses on the internal structure of ASC. The second is between-network analysis, which explores the relationship between ASC and other factors, such as academic performance. The present study focuses on a between-network approach; however, understanding the internal structure of ASC is needed to provide a comprehensive understanding of and rationale for the primary variables of interest. The relationship between ASC and academic outcomes is domain-specific (Wu et al., 2021). In a study of 4,495 German students between the ages of 17 and 19, Marsh et al. (2006) found that domain-specific ASC, such as math self-concept, was significantly related to multiple domain-specific academic outcomes, including standardized test scores, course selection (e.g., advanced math courses), and total GPA. Their results around verbal self-concept demonstrated similar domain-specific relationships; however, consistent with earlier findings, ASC in specific domains were not related to general SC (Marsh et al., 2006). Swann Jr. et al. (2007) asserted that the relationship between ASC and achievement is stronger when they demonstrate the same level of specificity, which would explain why subject-specific ASC would predict subject-specific achievement, but broad ASC may not have a strong relationship with subject-specific outcomes.

Research like this illustrates the importance of the multidimensionality of ASC when considering domain-specific outcomes, such as subject-specific grades.

In summary, the internal structure of ASC is accepted as multidimensional, and across most models, it is recognized as hierarchical. The structure of ASC drives both measurement of the construct and alignment with outcomes. Earlier models of ASC lacked empirical support for the theoretical structures posited (Marsh, 1990). Subsequent development of the theory aided in improvements to measurement of the construct and an understanding of ASC as a construct. Early literature that focused on both theoretical and empirical knowledge around ASC provides a foundation to understand the internal structure of ASC, which helps to contextualize the primary variable of interest in the present study. The next section provides a review of how ASC is formed at the individual level and its relationship to other factors.

Development of ASC and Relationships with other factors

Shavelson et al. (1976) asserted that ASC is informed by an individual's experiences with and perceptions of their environment. The purpose of this section is to detail how ASC is developed at the individual level and what factors may influence it.

Early findings about ASC and academic performance supported strong correlations between academic achievement in subject-specific domains and their corresponding ASCs (e.g., math ASC and math grades), and low correlations between subject-specific SCs (e.g., math ASC and verbal ASC) (Marsh et al., 1986). In response to these contradictory findings, Marsh (1986) developed the internal/external (I/E) frame of reference model to understand and address these relationships. The I/E model proposes two processes of comparison through which an individual forms their ASC. Social comparisons are considered an external frame of reference, while dimensional, or more subject-specific, comparisons are considered an internal frame of reference. Social comparisons are those where individuals compare against others to make judgements about the self (Gerber et al., 2018), while dimensional comparisons are those individuals make with other domains or subjects (e.g., math, verbal reasoning) (Möller & Marsh, 2013). A meta-analysis of the relationship between ASC and academic achievement in K-12 settings revealed a third comparison processes in the development of ASC (Möller et al., 2020), which are temporal comparisons, which individuals make against prior academic performance (Wilson & Ross, 2000). Evidence of each of these processes has been demonstrated in literature spanning various age groups.

Marsh & Hau (2004) investigated data from an international sample of 55,577 15-year-old students across 26 countries and found that students used both social and dimensional comparisons to form ASC across domains. This work highlights in particular the role of comparisons in making judgements about abilities across specific subjects. Möller et al. (2011) also demonstrated support for the I/E model through a sample of 1,508 school-age students in Germany. The authors investigated academic achievement across three time points for students in grades 5 to 8. Their work provided further evidence of the generalizability of the I/E frameworks model and expanded upon it through a longitudinal study to investigate a reciprocal I/E model (RI/E). The RI/E incorporates a reciprocal model of the relationships between ASC and academic achievement, where prior ASC predicts subsequent academic performance, which in turn predicts subsequent ASC. These results suggest the internal and external frames of reference continue to inform ASC over time.

Wolff et al. (2018) conducted a series of three studies to explore the role of social, temporal, and dimensional comparisons in self-concept. Their first study included 120 university students in Germany. The authors used manipulated feedback across a series of experimental groups to determine whether comparisons would impact students' ASC, which was measured through items specific to figure and word analogies. They found that while all feedback impacted ASC across groups, social comparisons had the most salient impact on ASC, and dimensional comparisons demonstrated stronger effects than temporal comparisons for both domains of ASC. In their second study, Wolff et al. looked at social, dimensional, and temporal comparisons in relation to math and verbal self-concept of 924 high school students in Germany. Students were asked to make comparisons, rather than receiving manipulated feedback like the participants in the first study, and the authors were able to replicate the findings for all three comparative processes, where social comparisons had the largest effect on math and verbal ASCs, and the impact of dimensional comparisons were stronger than temporal comparisons. The third study from Wolff et al. had two phases, and the authors incorporated a longitudinal approach to exploring the effect of comparison processes on ASC. This study included 3,054 elementary school students in Germany. ASC was measured through items specific to math and German (verbal) self-concept. The results of the third study support those from studies 1 and 2 and built upon the findings through the inclusion of academic performance over time, which demonstrated support for a reciprocal relationship between ASC and performance, as well as support for the RI/E model discussed by Möller et al. (2011).

The studies from Wolff et al. (2018) provide evidence of similar processes to form ASC across age groups and into adult learner populations. Wilson and Ross (2000) conducted a three-phase qualitative study of social and temporal comparison processes. The first two phases of the study included university students, while the third phase consisted of an analysis of biographical and autobiographical articles in popular culture magazines. In the phases specific to university-level students, social and temporal comparisons were common when describing themselves, both in phase one, where students were asked explicitly to consider both temporal and social comparisons in their self-appraisal, and in phase two, where students were asked to broadly describe themselves. In study two, social comparisons were more common when students described their intelligence (Wilson & Ross, 2000). This study supports the use of comparison in forming ASC in both adolescence and adulthood. These processes are important to understand as they may moderate the relationship between ASC and academic achievement both broadly and across specific domains (Möller et al., 2020).

In addition to the processes through which individuals form ASC, it is also important to consider other factors that may influence or impact ASC, particularly in adult learner populations. Studies have also demonstrated the importance of student-faculty interactions in the development of ASC (Kim & Sax, 2014; Komarraju et al., 2010; Plecha, 2002), as well as intrinsic and extrinsic motivation (Isiksal, 2010; Plecha, 2002) in college and university settings. Komarraju et al. (2010) found that students reported higher ASC when they had faculty who were respectful, who they considered approachable, and who were available to provide support outside of class. One study compared the relationship between ASC, advisor support, and sense of belonging among domestic and international graduate students (Curtin et al., 2013). They found that a positive advisor relationship was related to positive ASC for all students, but domestic students' ASC was more reliant on a sense of belonging, while sense of belonging and ASC were not related for international graduate students. These studies suggest that various aspects of the learning environment can inform ASC among college and university-level students. Studies have also shown that student well-being also plays a role in ASC. In a study of 244 first-, second-, and third-year pharmacy students in a professional degree program, Maynor & Carbonara (2012) study found a negative relationship between stress and ASC. These findings were similar to another study involving 361 first- and second-year pharmacy students where burnout was negatively related to students' perceptions of academic abilities (Kaur et al., 2020). These factors help to contextualize the experiences of adult learners and how they may impact ASC, particularly in the health professions, where students may have similar experiences.

In summary, ASC is formed through several comparative processes through which individuals make judgements about their academic abilities. ASC may be impacted by environmental and individual characteristics as well. It is necessary to understand how individuals form ASC to contextualize it as a primary variable of interest in the present study. The relationship between ASC and academic performance is explored in further detail in the next section. It is important to review what is known about this relationship both broadly in the literature and more specifically within the context of medical education to inform the present study.

ASC and academic performance

ASC is considered an important moderator for other academic factors, including achievement, engagement, course selection, and academic aspirations (Möller et al., 2011). The relationship between ASC and academic performance is of central focus in the present study. Understanding this relationship in the context of medical education can provide useful insights that drive improvement of educational experiences and academic outcomes of medical students.

Academic achievement is one of the most common outcomes explored in relation to ASC (Arens et al., 2021). Despite empirical evidence of this relationship, primarily demonstrated through correlations, the explanation of how the relationship works has been a subject of inquiry for decades (Möller et al., 2011). Early research into this relationship used one of two models: the skills development model and the self-enhancement model. In the skills development model, ASC is impacted by academic performance (Calsyn & Renny, 1977). The self-enhancement model presents the opposite relationship, where ASC influences academic performance (Calsyn & Renny, 1977). A third model, which posits that ASC impacts academic performance, which then informs subsequent ASC, integrates the skills development and self-enhancement models (Marsh et al., 2005). The reciprocal effects model (REM) has been widely adopted as the dominant model to understand and explore the relationship between academic performance and ASC (Marsh et al., 2005). In a study of 1,508 grade five students in Germany, Möller et al. (2011) tested the REM through longitudinal data consisting of student grades across three academic years (grades 5, 6, and 8). They found support for the REM across subject domains in math and verbal reasoning, where prior ASC predicted subsequent academic performance.

Academic performance is measured most through school grades, teacher ratings, and standardized test scores (Pinxten et al., 2010; Arens et al., 2021). Research contends that grades are more salient ASC than standardized test scores because of their availability and interpretability to students; they better enable social, temporal, and dimensional comparisons (Arens et al., 2021). In a meta-review of the relationship between academic self-beliefs and achievement, Valentine et al. (2004) asserted that there was no difference in effect size based on the type of achievement measure, which most commonly includes standardized test scores and class grades. Stronger relationships between ASC and performance have been found when the specificity of the constructs align (Pinxten et al., 2010); that is domain-specific ASC is more strongly related to domain-specific performance. In their study of 1,508 school-age German students, Möller et al. (2011) examined the relationship between domain-specific ASCs, measured by three items from the Self-Description Questionnaire II (SDQ-II) (Marsh, 1990), and grades on report cards in years 5, 6, and 8. The items used to measure ASC were the same across both subjects, but were modified for specificity in each domain; for example, the items measuring math ASC included, "Math is one of my best subjects." They found evidence to support a reciprocal relationship between ASC and grades across both subjects. Arens et al. (2017) also demonstrated evidence of a reciprocal model of academic performance and ASC among 3,425 German school-age students, focused specifically on math ASC and math performance. In this study, the authors measured ASC through a six-item measure developed by the Project for the Analysis of Learning and Achievement in Mathematics. Math performance was measured through school grades and scores on standardized math tests. There was one measurement point per school year from grades 5 to 9. Möller et al. found that the relationships between ASC and performance were significant across years regardless of whether grades or test scores were used. Findings from Seaton et al. (2014) also supported the REM. Their longitudinal study comprised data collected across two years and four timepoints, with two timepoints per year, from a sample of 2,786 Australian high school students. The ASC and performance metrics used in the study were specific to math. Math achievement was measured through math items from a norm-referenced achievement test, while math ASC was measured through six items from the SDQ-II (Marsh, 1990). The results of the study demonstrated a reciprocal relationship between math ASC and math performance across all four timepoints. These studies inform the present study in several ways; first, they provide empirical support for the REM and a longitudinal approach to studying the relationship between academic performance and ASC. Second, they illustrate the types of academic performance measures that may be used in primary and secondary educational settings.

Because the present study is specific to medical students, it is helpful to address studies more specific to adult populations. More global measures, like GPA, can represent the academic performance of college and university students, while students also have course-specific or subject-specific grades. Reynolds (1988) asserted that college grades provide a means by which students can make judgments about their abilities. Lent et al. (1997) studied 205 university students to understand the connection between ASC, self-efficacy, and performance in math. They found that ASC, measured through Reynolds (1988) Academic Self-Concept Scale (ASCS) and the Academic Adjustment Scale (Baker & Siryk, 1984), was strongly related to performance in math using a global measure of performance (GPA). Kornilova et al. (2009) also used GPA as a measure of academic performance in their study of 300 Russian undergraduate students. They found that academic self-concept, measured through seven items, and subjective evaluations of intelligence accounted for 42% of the variance in student GPA. In a study of 230 college students, Choi (2005) found that ASC was a significant predictor of term grades. That study included two measures of ASC to capture multiple levels of specificity; on a more global level, the ASCS (Reynolds 1988) was used, while math ASC was measured by seven items modified from an instrument used by Marsh (1992) in an earlier study. In a study of 170 nursing students in Israel, Khalaila (2015) found a direct relationship between ASC and academic performance, and this relationship was mediated by test anxiety and intrinsic motivation. Khalaila (2015) used a grade average from preclinical courses and clinical practice to measure achievement and used Reynolds' (1988) ASCS to measure ASC. While the present study will not include clinical practice, the results of Khalaila's study provide salient implications for using a global measure of academic performance across courses among students training in the medical field. These findings illustrate both the connection between ASC and academic achievement in college and university settings and the importance of other factors in relation to ASC. Overall, these studies support the use of both course and overall grades as an outcome in the current study. While these studies do not address the REM of ASC and academic performance, they do provide helpful insight into the use of different performance metrics to explore this relationship among adult learners.

In summary, research exploring the relationship between ASC and academic performance informs the current study in several ways; first, the REM is considered the dominant model of the relationship between the two constructs, which has been demonstrated in K-12 populations (Pinxton et al., 2010; Möller et al., 2011; Seaton et al., 2013; Arens et al., 2017). Second, studies in both adolescent and adult populations support the use of different constructs to measure academic performance, such as school grades, standardized test scores, and teacher ratings (Valentine et al., 2004; Pinxton et al., 2010). Studies that use more global performance metrics (Lent et al., 1997; Choi, 2005; Kornilova et al., 2009; Möller et al., 2011; Khalaila, 2015) have demonstrated the relationship between ASC and performance.

ASC and Performance in Medical School

The structure of evaluation and grading in medical education influences the learning context and role of ASC for learners. Research on ASC in primary and secondary education provides evidence to support a relationship between ASC and academic performance (Lent et al., 1997; Choi, 2005; Kornilova et al., 2009; Pinxton et al., 2010; Möller et al., 2011; Seaton et al., 2013; Khalaila, 2015; Arens et al., 2017). The findings around ASC in college and university settings provide a justification to explore this relationship in the context of other adult learners; however, this change in context should be addressed. One example of this is the competitive nature of medical school, which is preempted by an admissions process that stratifies applicants using both academic and non-academic factors (Baker et al., 2020). Many medical schools consider prior academic performance, such as grade point average or scores from the medical college admissions test (MCAT) as part of their selection into medical school. The MCAT was suggested for standard use as criteria for medical school applicants in 2001 to reduce the admission of students at high risk for academic failure (Albanese et al., 2003). Beyond the admissions process, the learning environment in medical school is also recognized for its competitiveness, and the residency application process can also be highly competitive. This may contribute to a student's motivation to perform well.

The Structure of Medical Education

Medical education includes two broad phases of the curriculum: the preclinical and clinical phases, also referred to as pre-clerkship and clerkship phases. The use of pre-clerkship, as opposed to preclinical, recognizes that students may have clinical exposure prior to their clerkships. For uniformity, and with consideration of an international body of literature around medical education in this chapter, the terms preclinical and clinical will be used moving forward. The Flexner Report, written more than 100 years ago, is still widely acknowledged for its role in shaping modern medical education. The Council on Medical Education (CME) proposed curricular and structural changes to medical schools in 1908, which included a change to include two years of laboratory sciences and two years of clinical rotations in teaching hospitals (Beck, 2004). In an attempt to drive reform of medical education, the CME requested the support of the Carnegie Foundation. Abraham Flexner, a high school teacher, was tasked by the Carnegie Foundation to evaluate the quality of American medical schools (Duffy, 2011). The reform efforts of the CME, driven by the Flexner Report, informed what is now a standardized approach to medical education (Beck, 2004). Modern medical education is credited to the Flexner Report, but the impact of the report has not been totally positive; one criticism of the report is that the more rigorous standards for selection into medical school created a barrier for economically disadvantaged individuals to careers in medicine (Beck, 2004).

While curricular changes have been the subject of reform in the last 100 years, the overall structure of medical education has remained intact; however, despite efforts for standardization across medical education, there is no uniform grading system (Hernandez et al., 2021). Grading across both phases is variable, though there are national standardized board exams required for licensure. These exams take place at the end of the preclinical and clinical phases of medical school during the undergraduate phase. The next section will detail measures of academic performance prior to matriculation into medical school, during the preclinical phase, and during the clinical phase.

Preadmissions performance

Academic performance is a factor of interest before students are accepted into medical school. As indicated, undergraduate GPA and MCAT scores are commonly used as factors in admissions decisions. MCAT scores are related to performance on the United States Medical Licensure Examinations (USMLE) Step 1 exam, which is why they are a proxy for medical knowledge prior to entering medical school (Giordano et al., 2016). In a longitudinal study of four matriculating classes across 119 medical schools, Dunleavy et al. (2013) found that a combination of MCAT scores and GPA predicted performance throughout medical school, as well as unimpeded progress to graduation, which the authors defined as individuals who were not dismissed or did not withdraw for academic reasons, graduated within five years of matriculation, and passed all three medical licensure exams. The authors noted that their findings were generalizable across schools. It is worth noting that the sample of students in their study took an older version of the MCAT that is no longer used, and one of the three USMLE step exams (Step 2 Clinical Skills) is no longer used by the National Board of Medical Examiners.

Preclinical performance

According to data from the AAMC, between 2015 and 2020, most medical schools used a pass/fail grading system in the preclinical curriculum. Other grading systems include a three-tiered honors/pass/fail system, a four-tiered honors/high pass/pass/fail system, numeric grades, and letter grades (AAMC, n.d.). While numeric grades were once the most common grading system, the shift to a pass/fail or other tiered grading system is attributed to attempts to reduce anxiety and competition (Gonnella et al., 2004). A single-institution study demonstrated improved student well-being after switching to a pass/fail curriculum (Bloodgood et al., 2009). These grading structures highlight internal summative assessments across individual schools, but students also take the USMLE Step 1 exam at the end of the preclinical curriculum. Step 1 is a standardized exam that measures the understanding of basic medical sciences (Cuddy et al., 2008). Historically, Step 1 scores played a role in residency selection (Giordano et al., 2016), though the role of Step 1 may be diminished as the exam becomes strictly pass/fail in 2022.

Summary

Academic performance before and during medical school is measured in different ways, some of which are standardized, and some that are not. Internal grading systems are variable across medical schools. USMLE Step 1 scores are standardized, and performance on this exam is particularly important for selection into residency programs (Giordano et al., 2016). Prior academic performance, such as GPA and MCAT scores, are common factors used for selection into medical school. GPA acts as a proxy for undergraduate performance, while MCAT scores represent prior medical knowledge (Giordano et al., 2016). It is helpful to understand how academic performance is measured throughout medical school to inform the most appropriate model to explore the relationship between performance and ASC. These measures represent academic performance and will be used in the present study to better understand the relationship between ASC and academic performance in med school.

Empirical Studies of ASC in Medical Education

Major studies

Medical students' perceptions of their learning environment, well-being and academic self-concept. Litmanen et al. (2014) conducted a study to understand whether exhaustion and lack of interest mediated a relationship between the learning environment and academic self-concept and whether perceptions of the learning environment, well-being, and self-concept differed across phases of the curriculum. The authors administered a questionnaire electronically to first- and fourth-year medical students. Their sample included 610 students from three medical schools in Finland. Two of the schools had an LBL curriculum with a total of 434 students represented, which included 251 students in the preclinical phase of medical school and 183 in the clinical phase. The third school had a PBL curriculum, with 176 students participating in the study. Among PBL students, 96 were in the preclinical phase and 86 were in the clinical phase. The results of a univariate analysis indicated students in the PBL curriculum reported higher ASC during their preclinical phase, but differences were not significant in the clinical phase. Using structural equation modeling, the authors found that exhaustion and lack of interest partially mediated the relationship between perceptions of the learning environment and academic self-concept.

The authors measured ASC through a single item asking medical students to compare their performance against that of their peers. The item had three possible response options, which asked students to indicate whether their grades were worse than, about the same as, or better than the average grade of their peers. Because it is a single-item measure, an internal consistency reliability coefficient could not be calculated. The authors did report a correlation coefficient between the single-item measure and student GPA based on a previous study to establish validity evidence. Jackman et al. (2011) also measured social comparison through a single-item measure, though their methodology differed in that the single item was used in combination with a multiple-item instrument to measure ASC. Similar to this study, Zhou et al. (2015) measured ASC through comparison with peers, though they utilized an instrument with multiple items.

While the single item used supports an operationalization of ASC as dependent on social comparison, the authors did not provide an in-depth explanation of the measure selected or justification for why they did not use another measure with more items. Other studies (Zhou et al., 2015; Jackman et al., 2011) used measures of ASC that included social or peer comparison, Jackman et al. (2011) also used a single item in their study, which was used to measure social comparison in addition to a multiple-item measure of ASC. The authors present prior validity evidence on the item but do not report evidence from their own study. Another potential limitation of the single-item measure is sensitivity. While a 3-point scale may provide sufficient sensitivity to detect differences between scores (Mitchell & Jolley, 2010), increasing the number of responses might increase the sensitivity of an instrument to better detect small differences among respondents. In other studies using social comparison methods (Zhou et al., 2015; Jackman et al., 2011), the items and instruments used 5-point Likert type responses. More response options may improve the sensitivity of an instrument, which impacts the interpretation. The authors described Finnish medical schools as lasting five years, which may present cultural differences in medical education that limit the ability to generalize to four-year medical schools.

Litmanen et al. found that ASC was different in the preclinical phase based on the type of curriculum, where preclinical students in PBL schools reported higher ASC than those in LBL schools, but there were no differences reported in the clinical phase. The findings suggest that the relationship between ASC and curriculum differs between preclinical and clinical students, at least in one type of curriculum. This informed the present study, as it focused on the preclinical phase of medical education. The study by Litmanen et al. provided some evidence of unique experiences relevant to ASC in the preclinical curriculum, but it is still unclear whether ASC changes during the preclinical years, which is of direct relevance to the present study.

Attitude towards problem-based learning and its relationship with locus of control and academic self-concept among medical students. In a study of 255 Malaysian phase one medical students, which the authors defined as students in their first and second years in the curriculum, Abdalla et al. (2019) sought to understand whether attitudes toward the learning environment are predictive of ASC and locus of control. They found that perceptions of PBL positively impacted ASC, where more positive perceptions of the curriculum were associated with higher ASC. The authors also compared the mean responses across each measure (ASC, internal locus of control, and perceptions of PBL) between first- and second-year students. Among these students, ASC was higher among first-year students. While cross-sectional, these findings suggest that there could be changes between the first and second year of medical school. Longitudinal studies into these changes could provide further support to generalize these findings.

Abdalla et al. presented ASC as a construct informed by experience and dependent on comparison with peers. The authors included 8 items on a questionnaire to measure ASC. The items were adapted from the Academic Self-Concept Scale (Liu et al., 2005). The authors did not indicate which items were included or their process for selection, though they did report a reliability coefficient for the ASCS of .72. The research team piloted the instruments among 20 medical students and indicated the process was followed with modifications, though the authors do not specify these changes.

Abdalla et al. used ASC and internal locus of control as dependent variables in two separate regressions. In each regression model, attitudes toward PBL were used as an independent variable. These methods were appropriate to answer their stated research questions; however, the authors did not explore any potential relationships between academic self-concept and locus of control in the introduction of their paper when presenting the existing literature. Locus of control has been reported in previous studies to predict ASC (Albert & Dahling, 2016), suggesting an established relationship between the two. The authors did not present or explore this literature. Further, in their analyses, the authors did not report any results of a correlation analysis. Such an analysis might have indicated whether a relationship existed between the two dependent variables (internal locus of control and ASC), which may have made two separate analyses inappropriate. The authors suggested that their findings support previous studies showing that learners in PBL have higher ASC than those in a non-PBL curriculum. The authors did not use a comparison group to support this conclusion, which might have helped strengthen the inference.

This study was relevant to the present study because ASC was measured among preclinical medical students. This study used a cross-sectional design, which limits the inferences based on the findings, because it is unclear whether changes in ASC would occur between first and second year within the same sample of students, or if some other difference between the groups included explain the difference in ASC. Because the school in the study was described as a five-year medical school, there may be cultural differences that limit the generalizability to four-year medical schools. The findings that first-year students reported higher ASC still suggested a potential difference between students based on what year they are in, which provides a foundation for a longitudinal analysis in the present study.

Psychological distress and academic self-perception among international medical students: the role of peer social support. Yamada et al. (2014) studied the relationship between psychological distress, academic self-perception, and peer support. The authors did not use ASC as a specific construct, though they did consider students' perceptions of their academic abilities, which aligns conceptually with ASC. Their participants were first- to sixth-year international medical students in the Czech Republic, and data was collected through an anonymous survey. The authors reported an interaction between peer support and psychological distress on academic self-perception and highlighted the need for social support for students.

In their study, Yamada et al. used academic self-perception as a proxy for academic performance. They measured academic self-perception using a subscale of the Dundee Ready Education Environment (DREEM) scale. This subscale included eight items, which the authors provided examples of (*'I am confident about passing this year'; 'I am able to memorize all I need'*), but they did not provide validity evidence. The items were scored from 0-32 and scores in the bottom 30% were considered 'poor' self-perception, while all scores above 30% were considered 'not poor.'

A major limitation of this study was that the authors use academic self-perception as a proxy for academic performance, rather than as independent constructs. The anonymous nature of the survey used to collect data limited the author's ability to link participants' survey responses with performance-related information, so student self-perception was used to determine their academic performance. The authors noted this as a limitation because the measure they used for academic self-perception was not validated for use as a measure of performance. In this study, Yamada et al. asserted that academic self-perception was generally related to psychological distress, and their primary question focused on the role of social support in this relationship; specifically, whether social support moderated the relationship between distress and academic self-perception. It is unclear why the authors considered self-perception to be a proxy for performance when they provided sufficient rationale to explore academic self-perception as an outcome of interest, rather than the academic outcomes or performance of students. Because they did not provide existing evidence to support the use of self-perception as a proxy, the inferences of their findings as related to performance are limited. The authors noted an additional limitation that the results of their study should not be generalized beyond international medical students learning in English in non-English speaking countries. This limitation makes it difficult to generalize the results of this study to the population in the present study. This study does provide some insight into medical student experiences, though implications for the present study are limited.

Big Fish in a Big Pond: a study of academic self concept in first year medical students. In their study of academic self-concept among first-year medical students in Australia, Jackman et al. (2011) conducted a multiphase, mixed methods study to explore changes in self-concept and self-evaluation among medical students before and after their first written assessments. Their study included 20 students in the quantitative phase and 13 in the qualitative phase, recruited from a class of 133 students. During the quantitative phase of the study, authors investigated ASC at two time points: before and after the first written assessment of student performance. The authors found no significant change in academic self-concept across the two time periods. They reported that self-concept scores were not related at the first time-point or second time-point, but social comparison at time one was associated with academic self-concept in time two. The second phase of the study included a qualitative approach to understanding academic self-concept through student interviews. They reported that students seemed to compare their performance against their peer group.

The authors hypothesized that academic self-concept would decline as a result of external feedback. The proposed relationship aligns with a skills development model, though this is not discussed explicitly by the authors. The authors conceptualized ASC as dependent on peer comparison. ASC was measured in the quantitative phase with the ASDQII (Marsh, 1990), an 8-point Likert-type agreement scale designed to measure ASC through appraisal of academic performance across academic domains. The authors also used a single-item measure of social comparison, where students reported how much better or worse they were academically compared with their peers, where a 1 indicated they were much worse and a 5 indicated they were much better. A single-item measure of peer comparison was also used by Litmanen et al. (2014). In contrast with the item used in Jackman et al.'s study, the single-item measure used by Litmanen et al. (2014) was used specifically to measure ASC, rather than a separate measure of social comparison, and the item used in that study was a 3-point Likert scale where students rated their typical grade as worse than, the same as, or better than the average grade of the class.

While Jackman et al. are the only researchers to use both quantitative and qualitative methods, their study presented significant limitations, beginning with a small sample size. The authors report a sample size of 20 students in the quantitative study and 13 in the qualitative study. This limits the generalizability of the findings and presents a potential limitation on the statistical power of the analysis. The authors acknowledged the small sample size and its impact on generalizability. In their presentation of the scales used to measure ASC, the authors mention previously established validity evidence but do not report their own. This further limits inferences from the study. Because academic self-concept may be influenced in part by comparison with others, the authors expected to find a relationship between the two constructs; however, they do not discuss whether this would have provided some form of convergent validity. Presentation of validity evidence would strengthen the study.

This study was one of two that measured ASC across multiple time points. A small sample size and context of Australian medical school limit the generalizability of the results, but the authors' finding of social comparison prior to assessment were related to ASC after assessment provided some evidence of social comparison in the development of ASC among medical students. Because this relationship was only demonstrated in these two time points, the inferences were limited. This study informs the current study through the exploration of the relationship between ASC and academic feedback; specifically, whether ASC changed in response to feedback. This relationship was relevant to the present study, as one of the research questions explored whether ASC changes during the preclinical phase. The ability to better understand student experiences as they progress through medical school could provide opportunities to improve learner outcomes. A major contribution from the study by Jackman et al. was the qualitative phase of their study, where student interviews revealed that social comparisons influence student ASC. This finding provides support for the role of social comparison in forming ASC (Wilson and Ross, 2000), which is important from both a developmental and measurement perspective.

The impact of self-concept and college involvement on the first-year success of medical students in China. In a longitudinal study of Chinese medical students, Zhou et al. (2015)

explored ASC between matriculation into college and the end of the first year. Academic achievement (measured through GPA) was the outcome of interest. They found that prior performance, prior ASC, level of involvement with homework, and faculty interactions positively impacted the development of ASC in the first year of medical school, which then had an indirect impact on academic performance in the first year.

The authors used a measure of ASC that relied on peer comparison. They described their measure as having five items related to academic ability, drive to achieve, mathematical ability, creativity, and intellectual self-confidence. These items provided a five-point scale where 1=lowest 10%, 2=below average, 3=average, 4=above average, and 5=highest 10%. This and other measures were administered across two surveys that the authors described as reliable based on prior evidence. While this study focused on medical students, the details of the instruments used indicated that these students were able to identify across two broad categories: medical majors and medical edge discipline. Medical majors included students studying clinical and basic medicine, while medical edge discipline included pharmaceutics, medical technology, nursing, and preventative medicine.

In a description of the relationship between the learning environment and self-concept, the authors described a “positive gain spiral” where ASC may influence behaviors in college which then impact subsequent self-concept. The authors further describe the relationship between self-concept and achievement as complex and informed by multiple factors (e.g., the learning environment). This study provides some support for a reciprocal effects model of the relationship between academic performance and ASC, though the authors noted in their analysis that they were unable to produce estimates for reciprocal effects to explore causal models. One limitation is the broad definition of medical student used in this study. International educational contexts have the potential to limit generalizability because of differences in the overall structure of medical school, but where some studies note the preclinical and clinical phases (Litmanen et al., 2014; Abdalla et al., 2019) of medical school, China has a unique medical education structure that is variable across medical universities (Lam et al., 2006), which may limit the generalizability of findings from Zhou et al. (2015).

Several aspects of this study informed the present study. A longitudinal design provided insight that cross-sectional studies do not; first, changes over time within the same population can be studied. Second, longitudinal studies are useful to explore the relationship between ASC and performance over time. The study from Zhou et al. (2015) helped to expand an understanding of the relationship between ASC and academic performance, particularly within medical students. What is still unknown is whether this relationship expands beyond the first year, and whether there are any significant changes in ASC during the preclinical phase that may help medical schools target opportunities to improve student outcomes and experiences.

Summary

Research into ASC among medical student populations informs the present study. The purpose of this study is to explore the relationship between ASC and academic performance among preclinical medical students, and while only two studies (Jackman et al., 2011; Zhou et al., 2015) focused on this relationship, other studies provide insight into ASC in the specific context of medical education. Zhou et al. (2015) demonstrated a relationship between ASC and academic performance among medical students, but Jackman et al. (2011) did not find evidence of a relationship in their study. Jackman et al. (2011) did provide support for the social comparison process in developing ASC among medical students in the qualitative phase of their study, which is useful when operationalizing ASC as dependent on peer comparison. The majority of studies within the literature used a cross-sectional approach to exploring ASC. Cross-sectional analyses enable exploration of academic self-concept within the skills development model and self-enhancement model. Reciprocal effects are best tested through longitudinal methods (Valentine et al., 2004). While Zhou et al. (2015) conducted a longitudinal analysis of ASC, they did not explicitly frame it as an exploration of the reciprocal effects model (REM), nor were they able to test for reciprocal effects between variables in their analyses. Jackman et al. (2011) also used a longitudinal approach, but their study was limited by an extremely small sample size, and where Zhou et al. measured ASC pre-college and at the end of the first year, Jackman et al. captured ASC before and after an assessment. Both studies focused on medical students in their first year only. These were the only two studies to explore the relationship between academic performance and ASC among medical students. While these studies are informative, there are still gaps, particularly when looking beyond the first year of medical school. Other research around ASC of medical students provided some insight into factors associated with it. Litmanen et al. (2014) and Abdalla et al. (2019) found that student perceptions of the learning environment were related to ASC. Inferences from the study by Abdalla et al. (2019) were limited as they did not explicitly study ASC as a construct, but rather academic self-perceptions. Yamada et al. (2014) found that peer support and psychological distress impacted ASC.

Measurement of ASC also varied across studies. Even for studies with similar aims, such as an exploration into the relationship between ASC and academic performance, there is limited generalizability if the instruments are not measuring the same things. Zhou et al. (2015) used a measure of ASC that relied on peer comparison, where Jackman et al. (2011) used a measure of ASC that captured an appraisal of academic performance in combination with a single social comparison item. While Zhou et al. (2015) found evidence of a relationship between ASC and academic performance, Jackman et al. (2011) did not. Differences in study design and sample size may have contributed to these mixed findings, but the differences in instrumentation would potentially limit the inferences from these studies had they both yielded statistically significant results. There were also differences in instrumentation around the two studies focused on the learning environment (Litmanen et al., 2014, Abdalla et al., 2019). Litmanen et al. (2014) used a single item to measure ASC, which was based on peer comparison, and while Abdalla et al. (2019) conceptualized ASC as reliant on peer comparison, they did not provide details on the selection process or content of the 8 items used from a modified scale. Yamada et al. (2014) used a measure of academic self-perception as a proxy for academic performance, which makes it difficult to draw conclusions about their findings. While variability in instrumentation poses an issue in the interpretation and subsequent generalizability of the findings, the findings from these studies across a range of measures is interesting. Findings from Litmanen et al. (2014) and Zhou et al. (2015) support the role of social or peer comparison to develop ASC, as well as qualitative findings from Jackman et al. (2011), while the findings from Abdalla et al. (2019) show support for development of self-perceptions derived from a combination of peer comparison and broader appraisal of abilities.

These studies informed the present study in several ways; first, the findings from Zhou et al. (2014) support the need for longitudinal exploration of the relationship between ASC and academic performance. The findings from Litmanen et al. (2014) suggest that there are differences in ASC across the preclinical and clinical phases, even if specific to perceptions of the learning environment. This supports the focus on the preclinical phase of the curriculum in the present study.

There is an extensive body of literature around ASC in primary and secondary educational settings, and studies in higher education have also contributed to the body of knowledge around ASC. With limited studies across the health professions, particularly among medical education, there is still a gap in the knowledge about ASC in these specific contexts. Understanding ASC in medical education is important to better understand student experiences, beliefs around learning, and may have implications for academic performance.

Chapter 3 Methodology

This chapter provides an overview of the methodology for the present study. This includes the study design, participants and sample, measures, procedures, plan for analysis, threats to validity, and a timeline for data analysis. The following research questions informed the study design and procedures:

RQ1: Does pre-admissions performance relate to ASC at matriculation?

RQ2: What factors influence academic performance during the preclinical phase?

RQ3: Does ASC change over time throughout the preclinical phase of medical school?

Researcher positionality

This study was influenced by my experience as a researcher. I was introduced to the construct of ASC through my work in an evaluation and scholarship unit within a medical school. My role included both research and evaluation responsibilities in the context of medical education, and I became interested in this area as one of the team members responsible for data analysis and reporting. As an evaluation team, we analyzed and reported aggregate data about ASC for evaluation purposes for several years, and my analysis of this data sparked questions about the broader role of ASC. Anecdotally, there were relationships between ASC and academic performance outcomes, but these were only ever explored in the context of a given cohort. Evaluation of the medical school curriculum and medical student performance, as well as medical student experiences, gave me insight into this specific educational setting. As I understood more about the learning environment and structure of the curriculum, questions about individual differences, specifically ASC, became more central to my interest. A focus on continuous quality improvement drove my research questions and my goal of a better understanding of the role of ASC for medical students and how these study findings may be used to ultimately improve their educational experiences.

Design

This study involved the implementation of a correlational quantitative research design to conduct longitudinal analyses of secondary data for three cohorts of preclinical medical students at an urban medical school in the Mid-Atlantic. A correlational research design was appropriate to understand the relationship between variables of interest; specifically, ASC and academic performance. A longitudinal design enables better understanding of this relationship over time. Secondary retrospective data was used for analysis in this study. All survey data was collected with the primary purpose of evaluation.

Population

The population for this study was medical students who completed the preclinical phase of the curriculum. Medical schools in the US range in size from under 100 total students to over 1,100 (AAMC.org, 2022), with around 800 students enrolled at the study site. Class size on average during the study period included between 170 and 185 students per entering class (Table 1), so the overall possible sample size based on class size was approximately 600 students. Analyses included data from the graduating classes of 2022, 2023, and 2024, resulting in an overall study sample of 495 students (Table 1). Response rates were based on the class size at matriculation. A total of 151 students from the graduating class of 2022 were included for analysis, representing 84% of the matriculating class that was surveyed. A total of 171 students from the class of 2023 were included for analysis, representing 93% of the class at matriculation. A total of 173 students from the class of 2024 were included, representing 97% of the cohort.

The preclinical phase of medical school at the study site spans matriculation to the end of the second (M2) year. This is a single-institution study. All ASC data was collected through survey administrations, which include a combination of paper surveys and electronic surveys depending on the time of data collection.

Table 1. Description of study sample by cohort

	Sample Size		
Cohort	n Cohort Size at matriculation	n Study sample	% Study sample
Class of 2022	180	151	31%
Class of 2023	184	171	34%
Class of 2024	178	173	35%
Total	542	495	100%

Survey description

Curriculum evaluation surveys varied in length depending on the time point during which they were administered, with surveys ranging from a total of 71 items to 169 total items and 10 to 12 instruments. For the purpose of this study, instruments only included existing measures with validity evidence Several individual difference measures and well-being measures were included across surveys, including those meant to measure goal orientation, self-regulated learning behaviors, resilience, and distress. Across all time points included in the present study, surveys included between 6-12 separate instruments. The ASC measure developed by Liu et al. (2005) was included among the individual difference instruments. In academic year 2018-19, a survey was introduced at the end of M1 year as part of a continuous curriculum evaluation cycle; prior to this change, ASC was only collected at matriculation, end of M2 year, and later time points. In response to the COVID-19 pandemic, several abbreviated versions of the survey were administered in Spring 2020. The survey administrations impacted by this change are noted in Table 2.

A series of questions specific to curriculum evaluation and student satisfaction were included on every survey, though questions were tailored to each cohort specifically, such as questions evaluating experiences during M1 year. More details are provided for each cohort in Table 2.

Survey Administration and Data Management

Data for the class of 2022 were collected between fall of 2018 and spring of 2020, data for the class of 2023 were collected between fall of 2019 and spring of 2021, and data for the class of 2024 were collected between fall of 2020 and spring of 2022. Each cohort had three time-points of survey data, during which ASC was collected: matriculation into medical school (Fall), the end of M1 year (Spring), and the end of M2 year (Spring). There were three time points of performance data of interest: performance prior to medical school, school rank quartile at the end of M1 year, and school rank quartile at the end of M2 year. Data from all three cohorts were combined for analysis.

All surveys were managed by one or more members of the evaluation team. A member of the evaluation unit typically attended a class or orientation session prior to survey administration to discuss the purpose and contents of the survey. During this time, students were informed at each survey collection that their data may be used for research purposes and that the surveys were completely voluntary. Students were also provided with an information sheet that details the survey, and what the data might be used for (e.g., evaluation, research).

Prior to 2019, paper surveys were administered in person during an orientation or class session. Beginning in 2019, all surveys were administered electronically via Qualtrics (Qualtrics, Provo, UT). An email list of current students in each cohort was used to deliver a unique link to the survey. Electronic surveys were timed around specific orientation or class sessions to allow for a targeted information session, where a member of the evaluation unit explained the purpose and potential use of survey results, including both evaluation and research. The matriculation survey (time 1) occurred in July or August during an orientation session in the first week of school. All other surveys (timed 2 and 3) were administered between April and June, depending on when the academic year ended for each cohort. In response to COVID-19, beginning in 2020, a monetary incentive was provided in the form of a random drawing for a $50 gift card due to concerns about low response rates. Incentives were offered for all survey collections except for matriculation. Abbreviated surveys for the end of M1 and end of M2 groups were administered in 2020 in response to COVID-19.

Final survey response rates were calculated as the number of students who completed or partially completed the survey out of the total number of students enrolled in that cohort at the time of survey administration. Incomplete surveys with responses for one full instrument, out of the total instruments comprising the survey, were recorded as partial if a response was not recorded for all items. If respondents began a survey but did not complete a single full instrument, their responses were not retained for analysis. Class size fluctuated over time due to various factors, such as students with an academic or medical leave of absence, those who must remediate, and students in the MD-PhD program who do not follow the same trajectory as their peers after M2 year. The final sample for this study included students with ASC and outcomes data whose original graduating year aligned with their actual graduating year. Sample sizes for each cohort were based on the class size at matriculation.

This study was approved exempt under IRB HM20024485. Data for the study was deidentified, and a unique study ID was created for each student in the overall sample to allow for linking across data sources.

Table 2. Description of surveys for classes of 2022-2024

	Survey Time point	Number of items[a]	Number of measures[b]	Method of administration	ASC Version[c]
Class of 2022	Matriculation (Time 1)	169	12	Paper	19-item
	End of M1(Time 2)	123	9	Electronic	19-item
	End of M2 (Time 3)	71[d]	6	Electronic	9-item
Class of 2023	Matriculation	138	10	Electronic	19-item
	End of M1	63[d]	6	Electronic	9-item
	End of M2	123	8	Electronic	9-item
Class of 2024	Matriculation	130	11	Electronic	9-item
	End of M1	107	9	Electronic	9-item
	End of M2	102	7	Electronic	9-item

[a] Number of items includes both quantitative and qualitative survey items
[b] Measure refers only to existing instruments with validity evidence; it does not include items created by the evaluation unit for evaluative purposes
[c] The version of ASC designed by the authors included 19 items and two subscales. One subscale was removed from the survey after AY2018-19
[d] Abbreviated surveys were administered in Spring of 2020 during the COVID-19 crisis

Variables

As part of the continuous curriculum improvement cycle, medical students at the study site were surveyed about their experiences, learning behaviors, and attitudes, in addition to their perceptions of the learning environment and overall feedback about the curriculum. The ASC survey items from these surveys form the basis for the variables that were explored in this study.

Independent variables

ASC. ASC was measured through a modified version of the *Academic Self-concept Scale* (ASCS) (Liu et al., 2005). The original scale contains 19 items that use a 4-point Likert-type scale, where 1=strongly disagree and 4=strongly agree. There are two subscales: student effort and student confidence. When first administered to medical students at the study site, the ASC measure included all 19 items, but the measure was subsequently modified to include only the confidence subscale, which has nine items. For details on which survey administrations this impacted, see Table 1. Four items were negatively worded, which were then reverse coded to calculate a mean response across all nine items. The modified 9-item version of the Academic Self-concept Scale was included on every phase of the evaluation survey throughout medical school. For survey administrations with the 19-item version of the ASCS, only the 9 items for the confidence subscale were included for analysis. One item was modified to better align with the context of medical education. The original item, which read, "If I work hard, I think I can go to the Polytechnic or University," to, "If I work hard, I think I can match well for residency."

Validity evidence for the ASCS was established by Liu et al. (2005) in the initial development of the scale. Subsequent evidence of scale validity within the context of medical students, which included the modified item, was demonstrated by Stringer (2018). For the present study, Cronbach's alpha (Cronbach, 1951) was calculated to determine scale reliability, where a value of .70 is sufficient to demonstrate reliability (Nunnally, 1978).

ASC was first collected when students matriculated into medical school, then again after students completed each academic phase (M1 and M2 years). ASC was measured at three different time points from matriculation (fall enrollment, time 1) to the end of the second (M2, time 3) year.

Outcome variables

Student performance. Student performance was measured through several metrics. These included:

- Undergraduate GPA (0-4.0)
- Medical College Admissions Test (MCAT) score (472-528)
- Student rank quartile at the end of M1 year
- Student rank quartile at the end of M2 year

Undergraduate GPA and MCAT scores were used as indicators of academic performance prior to medical school and are collected during the admissions process. All medical school applications use the American Medical College Application Service (AMCAS). Undergraduate GPA was a total score out of 4. The average GPA of the study sample was 3.73. MCAT scores for the study sample ranged from 502-526. The average MCAT score was 512.02.

Academic performance during the preclinical phase was measured by course grades and academic rank quartile. Academic rank quartile at the end of M1 and rank at the end of M2 were included for analysis. At the end of each academic phase, a weighted average of course grades was calculated based on the number of weeks of each course. Rank was inversely scored, where lower scores indicate better performance. Rank was not reported, which means students did not receive a rank, and it was not included in the medical student performance evaluation for residency; however, it represents their performance across courses and can be used as a proxy for overall performance across each academic year. Internal grading practices vary across medical schools, and there is limited literature on how other schools calculate or use academic student rank, if at all.

Demographic variables

Several demographics factors were included for both descriptive purposes and as covariates. Student demographics include:

- Age at matriculation
- Underrepresented Minority (URM) status
- Gender

Student age at matriculation is included for descriptive purposes. Student age ranged from 20 to 39 years old. The average age at matriculation was 24. URM status comprised students who identify as American Indian or Alaska Native, Black or African American, Native Hawaiian or other Pacific Islander, and/or Hispanic, Latino, or of Spanish Origin. URM status was included in the analyses for research question two, which addresses the relationship between ASC and academic performance. Of the total sample, 11% of students were URM and 89% were non-URM. Student gender was a binary construct that includes male and female, which was collected during the admissions process. Female students made up 54% of the sample, while male students made up 46% of the sample. Student gender was included in the analyses for research question two as a covariate.

Data preparation

The first stage of data preparation was to link students' ASC data across timepoints and create a primary dataset for analysis. For each cohort, this included linking a total of three distinct data points: ASC at matriculation (time 1), ASC at the end of M1 year (time 2), and ASC at the end of M2 year (time 3). The unique study identifier was used to link cases, and a dataset was generated for each cohort before merging all files together and linked to performance and demographic data. Cases were identified for exclusion during this stage. The final merged file contained 640 total cases. Of these, 41 cases were missing performance or demographic information. A total of 48 cases were missing ASC item-level data for all three timepoints, so values could not be imputed. Finally, 56 cases were removed due to misaligned graduating years, where the original graduating year did not match the current graduating year, which is an indicator of an off-cycle student. Once an initial review of data was complete, a total of 495 cases remained where students had relevant performance data and at least one time point for ASC.

Missing data

Once initial data cleaning was completed, the final working dataset was reviewed for missing data at the item level. Time 1 had the highest completion rate, with 96% of survey data completed or partially completed, and 4% missing data. Eight survey responses were missing data for the entire ASCS. Time 2 had the lowest completion rate, with 59% of completed or partially completed ASC items, and 41% missing data. Two cases were missing ASCS data across all items. Time 3 had a completion rate of 76%, with two cases missing data listwise, and 24% missing data overall.

Multiple imputation (MI) is a statistical method to manage missing data where existing values are used to predict the missing values (Wayman, 2003). MI is appropriate when data are missing completely at random (MCAR), where the missing values are assumed to be unrelated to other variables. Data that is MCAR may result in a loss of statistical power (Graham, 2009). While scores are computed for ASC, a missing data analysis was conducted at the item-level. Little's MCAR test (Little, 1988) was conducted to test this assumption. The test was non-significant (p>.05), indicating that multiple imputation was appropriate. Schafer and Olsen (1998) recommended between 3 and 5 imputations for moderate levels of missing data, but more recent recommendations suggest a larger number of imputations based on the proportion of missing data (Graham et al., 2007). Multiple imputation was conducted on the ASC data with a total of 40 imputations. No other variables were included for imputation. The imputation added a total of 253 observations. To assess the sensitivity and robustness of the multiple imputation models, analyses using imputed data included models with complete cases (i.e., only cases where ASC data was recorded at all three time points) and estimated models using imputed data. The results of the analyses were compared between the complete case data and multiple imputation data to assess sensitivity and robustness.

Data Analyses

Power

One consideration for this study related to the sample was statistical power. Power refers to the ability to detect statistically significant differences where they exist. Insufficient power may increase the likelihood of a type II error, which occurs when a researcher fails to reject the null hypothesis when it is false. One way that power was addressed in this study was through an analysis of potential change in ASC over time. A repeated measures analysis was used to address this question. Repeated measures, or within-subjects designs, reduce random error due to differences at the individual level. This design also increases the number of observations for each participant, which increases the power (Guo et al., 2013; Lu et al., 2013).

Descriptive analysis

A descriptive analysis of the data was conducted to understand the overall structure of the data, as well as to test the assumptions appropriate for each analysis. Univariate analysis included descriptive information such as means and frequencies where appropriate. An analysis of assumptions included tests of normality to explore the distribution of the data. Normality of distribution was assessed for Kurtosis and Skewness. This step is important to inform descriptive statistics and statistical analyses, such as whether data are skewed or require non-parametric tests. Further analyses were aligned with each specific research question.

Research question 1. To address question one, bivariate correlation and linear regression analysis were conducted to determine whether there is a relationship between pre-admissions performance metrics and ASC at matriculation (time 1). Correlation coefficients indicate the magnitude of a relationship between two variables. While Cohen (1988) recommended that coefficients of r=.10, r=.30, and r=.50 be interpreted as small, medium, and large effects respectively, Gignac & Szodorai (2016) recommended the use of r=.10, r=.20, and r=.30 with an interpretation of relatively small, typical, and relatively large respectively. These recommendations were the result of a meta-analysis with the purpose of determining normative guidelines for testing individual differences (Gignac & Szodorai, 2016). Cohen's (1988) recommendation for interpretation of correlation coefficients is common practice, but Gignac and Szodorai's (2016) suggestion for interpretation will also be given consideration. In addition to a correlation analysis, ordinal regression was conducted to determine what amount of variance in ASC at matriculation is explained by pre-admissions performance. This analysis is appropriate for the investigation of ordinal variables, such as those with Likert-type responses.

Research question 2. To address the second research question, a Spearman correlation was conducted to determine relationships between performance and ASC. Spearman's correlation is a non-parametric test that is appropriate when relationships between continuous and rank variables are explored. Ordinal regression of multiple imputation data was used to analyze longitudinal data collected across three timepoints: matriculation into medical school, the end of first year, and the end of second year. Ordinal regression is appropriate when the outcome of interest represents an ordinal or rank value. The outcome in this analysis is performance, which is represented by rank quartile. Lower quartiles indicate better performance. A bivariate correlation analysis was conducted to explore relationships between each of the key variables of interest. This analysis included ASC time points 1 and 2, rank quartile at the end of M1 year, rank quartile at the end of M2 year, and MCAT scores. Because rank is an ordinal variable, Spearman's correlation was used. A series of regressions were run to explore relationships between each time point.

In the first analysis, rank quartile at the end of M1 year was the outcome, with ASC time 1, MCAT scores, URM, and gender as predictors. In the second analysis, rank quartile at the end of M2 year was the outcome, with ASC time 2, rank quartile at the end of M1, URM status, and gender as predictors.

Research question 3. Repeated measures one-way analysis of variance (ANOVA) was used to determine whether there were mean differences in ASC across times 1, 2, and 3. ANOVA is used to analyze mean differences for three or more groups, and repeated measures ANOVA allows for testing means within the same population over time, though the results only indicate whether there are differences and not where those differences are. Post-hoc tests were conducted to determine which time points differed significantly.

Chapter 4 Results

Results from Chapter Three are presented in this chapter, which includes assumptions tested, descriptive analyses, and findings from the primary analyses. Finally, results of a bivariate correlation analysis, ordinal regression analysis, and repeated measures ANOVA are presented. Analyses were conducted in IBM SPSS Statistics for Windows, version 28 (IBM Corp., Armonk, N.Y., USA) or Stata 13 (Statacorp, 2021). These analyses address three primary research questions:

RQ1: Does pre-admissions performance relate to ASC at matriculation?

RQ2: What factors impact academic performance during the preclinical phase?

RQ3: Does ASC change over time throughout the preclinical phase of medical school?

Statistical Assumptions and Descriptive Statistics

Assumptions

Mean values for ASC at time points 1, 2, and 3 were all normal. Distribution of overall MCAT and GPA were also normal according to the recommendations for interpretation by West et al. (1996), where an absolute skew value greater than 2 indicates skewness, and an absolute value greater than 7 indicates kurtosis. MCAT scores were also normally distributed, but GPA skewness values indicated they were skewed (See Table 3). Because this violated the assumption of normality, and because there was little variability across values, GPA was excluded from subsequent analyses.

A missing data analysis was conducted to review missing data at the item level. Data were determined to be MCAR based on non-significant results of Little's MCAR test (Little, 1988). Multiple imputation was used to impute missing ASC values with a total of 40 imputations. Research questions 1 and 3 were addressed using the original data, while imputation data was used to test the models in research question 2. Descriptive statistics demonstrated that mean values for ASC were similar enough between the observed and imputed data to justify the use of original data for a repeated measures ANOVA despite missing data.

Descriptive statistics

Table 3. Descriptive statistics for ASC and performance outcomes

	N	Mean	Standard Deviation	Skewness	Kurtosis
Matriculation (Time 1)	477	3.12	0.32	-0.21	0.54
End of M1(Time 2)	292	2.91	0.45	-0.37	0.39
End of M2 (Time 3)	375	2.89	0.43	-0.22	0.36
GPA	495	3.74	.21	3.26	.22
MCAT	495	512	4.07	.57	.22

Descriptive statistics for demographic characteristics are presented in Table 4. Age at matriculation ranged from 20 to 39. The mean age of the sample was 24. URM students comprised 11% of the study sample, while non-URM students made up 89%. Female students made up 54% of the study sample, with 46% of the sample represented by male students. These numbers were representative of the overall student population.

Table 4. Descriptive statistics for demographics variables

	N	%	Mean	Standard Deviation
Age	495		24	2.24
Male	228	46%		
Female	267	54%		
URM	53	11%		

Non-URM	415	89%

Reliability

Cronbach's alpha coefficients were calculated for ASC at each time point to demonstrate reliability of the measure. For ASC at matriculation, $\alpha = .74$. The alpha coefficients for ASC at the end of M1 and end of M2 year were .84 and .83 respectively. Alphas for all three time points demonstrated acceptable reliability. Reliability at matriculation was lower than the later time points, which suggests a slight difference in responses across the same group of students. The ACS instrument measures confidence in academic ability, and includes several items about performance in courses, such as perceptions their instructors have about the student, or how they perform on assignments. During matriculation, responses to these items may be based more on past experiences, as students wouldn't have practical experience of medical school. Students are better able to respond with current experiences by the end of M1 and M2 years, which could explain the slight increase in reliability.

Bivariate correlation and regression analysis

The relationship between ASC at matriculation (time 1) and MCAT score was statistically significant ($p<.05$). The Pearson's correlation coefficient was relatively low, $r=.09$, indicating a weak relationship between the two variables, according to recommendations for interpretation by both Cohen (1988) and Gignac & Szodorai (2016). The linear regression analysis was also statistically significant ($p<.05$), although MCAT scores explained less than 1% of the variability in ASC at matriculation (time 1). MCAT scores were not a significant predictor of ASC during matriculation to medical school. Correlation coefficients are presented in Table 5. While not practically significant, the direction of the relationship demonstrated a positive impact of MCAT scores on ASC upon entry to medical school, where higher MCAT scores are associated with higher ASC.

Table 5. Pearson's correlation of ASC and Preadmissions Performance

	ASC Time 1	MCAT
ASC Time 1	--	
MCAT	0.09*	--

*. Correlation is significant at the .05 level (2-tailed).

Ordinal logistic regression

The multiple imputation data were used for the ordinal regression. An estimate model was produced to provide pooled results in a single model. The results of the Spearman's correlation are presented in Table 6. The only relationships without a significant Spearman correlation were MCAT scores and ASC. The Spearman rank correlation between rank quartile at the end of M1 and the end of M2 was .81, p <.01. Rank quartile at the end of M1 and end of M2 were both related to ASC across all three time points, with larger correlation coefficients in later time points. The lower the quartile, the better a student's rank. Higher ASC and MCAT scores had a positive relationship with quartiles, where higher ASC and MCATs were associated with lower rank quartiles.

Table 6. Spearman's correlation of ASC and Performance Metrics

	Rank Quartile 1	Rank Quartile 2	ASC Time 1	ASC Time 2	ASC Time 3	MCAT
Rank Quartile 1	--					
Rank Quartile 2	$.805^{**}$	--				
ASC Time 1	$-.146^{**}$	$-.148^{**}$	--			

ASC Time 2	-.293**	-.265**	.412**	--		
ASC Time 3	-.410**	-.418**	.358**	.530**	--	
MCAT	-.263**	-.184**	0.051	0.052	0.063	--

**. Correlation is significant at the .01 level (2-tailed).
*. Correlation is significant at the .05 level (2-tailed).

Analysis 1

ASC at matriculation and MCAT scores were statistically significant predictors of rank at the end of M1 year. For a one-unit increase in MCAT scores, the odds of a student being in a higher rank quartile decreased by 12%. For a one-unit increase in ASC scores, the odds of being in a higher rank quartile decreased by 61%. Rank was an inverse variable, where lower values indicated more optimal performance outcomes. These models indicate the likelihood of being in a higher rank quartile, where the first quartile is the reference category. For both MCAT scores and ASC, there was a positive relationship with performance, where higher scores were associated with a lower rank quartile. URM status and gender were not significant predictors in the model. The results are presented in Table 7. Table 8 contains the results of the ordinal regression using complete cases only. The imputed models contained a total of 468 observations, while the complete case data included 215 observations. The overall significance of the estimated model using imputed data was F<.001, and the significance of the Chi-square for the complete case analysis was <.01. Differences across models suggest the use of multiple imputation data allowed for detection of meaningful differences across variables.

Table 7. Ordinal logistic regression of factors influencing rank quartile at the end of M1 with imputed data

	Odds Ratio	Standard Error	t	p value
MCAT Scores	.88	.20	-5.72	<.001
ASC Time 1	.39	.11	-3.39	.001
URM	1.23	.33	.77	.44
Male	.89	.15	-.72	.47

Table 8. Ordinal logistic regression of factors influencing rank quartile at the end of M1 with complete case data

	Odds Ratio	Standard Error	z	p value
MCAT Scores	.90	.03	–2.92	.004
ASC Time 1	.54	.20	-1.62	.10
URM	1.62	.61	1.28	.20
Male	.76	.19	-1.10	.27

Analysis 2

ASC at the end of M1 year and rank quartile at the end of M1 year were statistically significant predictors of rank quartile at the end of M2 year. Prior academic performance, represented by rank at the end of M1 year, was the strongest predictor of rank quartile at the end of M2 year, where a one unit increase in rank quartile at the end of M1 increased the odds of being in a higher rank quartile by 892%. This suggests that there is little mobility in rank quartile between M1 and M2 year. For every one unit increase in ASC, there was a 48% decrease in the odds of being in a higher rank quartile. Where rank quartile at the end of M1 year was positively associated with rank quartile at the end of M2 year, ASC and rank quartile at the end of M2 year were also positively related, where higher ASC corresponded with the likelihood of being in a lower rank quartile. URM status and gender were not significant predictors in the model. The results are presented in Table 8. Table 9 contains the results of the ordinal regression using complete cases only. The imputed models contained a total of 468 observations, while the complete case data included 215 observations. Overall model significance was similar across models, though estimates demonstrate an increased ability to detect meaningful differences in the multiple imputation data.

Table 9. Ordinal logistic regression of factors influencing rank quartile at the end of M2 with imputed data

	Odds Ratio	Standard Error	t	p value
Rank quartile at the end of M1	9.92	1.40	16.22	<.001
ASC Time 2	.52	.14	-2.36	.02
URM	1.16	.34	.50	.61
Male	1.14	.22	.66	.51

Table 10. Ordinal logistic regression of factors influencing rank quartile at the end of M2 with complete case data

	Odds Ratio	Standard Error	z	p value
Rank quartile at the end of M1	13.58	3.18	11.13	<.001
ASC Time 2	.66	.24	-1.10	.27
URM	1.15	.49	.33	.74
Male	.96	.29	-.13	.89

Repeated Measures ANOVA

Repeated measures ANOVA was conducted to compare ASC across all three timepoints from matriculation to the end of M2 year. Mauchley's test of sphericity was significant, $p<.001$, indicating the assumption of sphericity was violated. Because sphericity was violated, and the Greenhouse-Geisser $\varepsilon > .75$, Huyn-Feldt corrected results were used. The results of the ANOVA indicated a statistically significant difference in ASC over the three timepoints, $F\ (1.73, 386.32) = 58.60$, $p<.001$, $\eta^2 = .21$. A Bonferroni adjustment was used for the post-hoc test, which demonstrated statistically significant differences between times 1 and 2 (0.21 (95% CI, .16 to .26), $p<.001$), and between times 1 and 3 (0.23 (95% CI, .18 to .28), $p<.001$). There was not a significant difference in ASC between timepoints 2 and 3 (0.19 (95% CI, -.02 to .06), $p=.31$), but ASC did decline from time 2 to time 3. The largest gap in ASC scores was between time 1 and time 3, demonstrating an overall decline over time during the preclinical phase. These results demonstrated a larger decline in ASC between matriculation and the end of M1 year, followed by a smaller decline between the end of M1 and end of M2 year.

Chapter 5 Discussion

The purpose of this chapter is to discuss the results of the study. This includes an interpretation of results within the context of existing literature about ASC within medical education, as well as implications for future study, practical application of results, and a review of the limitations.

Major Findings

Prior academic performance and ASC at matriculation

All three research questions yielded statistically significant results. There was a statistically significant relationship between academic performance prior to medical school and ASC during matriculation to medical school, but the overall correlation between these variables was weak, which suggests this relationship was not a practically meaningful one. While MCAT scores may be a useful tool for medical schools to identify candidates during the admissions process, the study results suggest it is less useful to understand student factors upon matriculation to medical school. Literature around the predictive validity of MCAT scores has primarily focused on student performance on licensing examinations (Dunleavy et al., 2013), though studies have established predictive validity of MCATs for performance during the preclinical phase (Donnon et al., 2007). These licensing examinations typically begin at the end of the preclinical phase. Statistical significance is common with large sample sizes (Sullivan & Feinn, 2012), and the weak correlation between MCAT scores and ASC suggested that MCAT scores do not explain any meaningful variability in ASC at matriculation in this study. In their study of first-year medical students, Zhou et al. (2015) found that higher pre-college national exam scores positively influenced pre-college ASC. Those findings provide support for the role of prior academic performance on ASC at matriculation, though these results are difficult to generalize or compare to MCAT scores. Where the National College Entrance Exam (NCEE) in China happens prior to college entrance and occurs during high school, MCATs are typically taken after a baccalaureate (undergraduate) degree is achieved. The NCEE may be more comparable to SAT scores in the United States because of the timing and more general content of the exam, where the MCATs include sections that are more specific to the practice of medicine, including foundations for biological, chemical, and physical foundations of living systems, in addition to section on social and psychological behavior and critical thinking. These differences in exam content and timing limit the ability to compare the findings of the present study and those of Zhou et al. (2015).

Given a strong theoretical foundation for the relationship between academic performance and ASC, and the specific focus on the MCATs on foundational knowledge of medical school, MCATs were hypothesized in this study to have a significant impact on ASC at matriculation, as students with higher scores may be more confident in their academic ability when starting medical school. For example, Jackman et al. (2011) used the Big Fish Little Pond Effect (BFLPE) as a theoretical framework to explore the impact of feedback on ASC. The BFLPE theory provides an explanation for why students may have higher ASC upon entry to medical school, and the authors argue that social comparison underscores this theory. Within the BFLPE framework, high-ability students are likely to perform better among average-ability peers (big fish in a little pond) than to be a high-ability student among high-ability peers (little fish in a big pond). This assertion is based on research from Marsh et al. (2008), which suggested students use the accomplishment of peers as a reference point for their own abilities or accomplishments. Jackman et al. (2010) did not find evidence to support this framework within the quantitative phase of their study, but results from the qualitative phase of the study demonstrated the role of social comparison in developing ASC. A major focus of the present study was the relationship between ASC and academic performance during medical school, and results from Jackman et al. (2011) emphasize factors that influence and explain this relationship; specifically, peer comparison. Social comparison against peers provides a potential explanation for one of the ways medical students develop ASC. Several items on the ASCS used in the present study included peer comparison, which underscores the role of social comparison when assessing ASC.

Despite the present study's statistically significant relationship between academic performance prior to admissions (MCAT scores) and ASC at matriculation into medical school, the overall strength of the relationship was weak. Acceptance and subsequent matriculation into medical school may be the largest factor explaining ASC at matriculation irrespective of performance as represented by undergraduate GPA or by MCAT scores. Because GPA was dropped from the study due to skewness and low variability, it is difficult to determine its potential role in predicting ASC at matriculation where MCATs could not. Selection into medical school is a rigorous process, where schools work to recruit high-performing students likely to be successful in their academic and future medical career. Zhou et al. (2010) determined that one in three prospective medical students repeat the MCAT each year, and schools use varying processes to assess multiple scores. The authors found that as the number of attempts increased, the likelihood of success on licensure exams decreased. While MCATs are required for most accredited medical schools in the US, higher scores may be mitigated by the number of attempts; for example, while a prospective student may have a high MCAT score, it may be their second or third attempt, which could impact their perceptions of their abilities. Number of attempts on the MCAT was not included as a variable in the present study, but it could provide insight into both ASC and subsequent performance in medical school. This is one possible explanation for why the admissions process, which has become increasingly holistic over time (Conrad et al., 2016), and subsequent acceptance into medical school may bolster confidence more than a single performance metric.

Factors influencing academic performance

ASC was a statistically significant factor in predicting subsequent academic performance, as measured by rank quartile at the end of each academic year within the preclinical phase. In both analyses where rank quartile was the outcome, prior academic performance was the most significant predictor. In the first model, MCAT scores were used as an indicator of academic performance prior to medical school to predict rank quartile at the end of M1 year. In model two, rank 1 quartile was the strongest predictor of quartile in rank 2. ASC was also a significant predictor of the likelihood of being in a lower rank quartile, which is a more optimal outcome. In both models, ASC was positively associated with rank quartile. These models provide evidence of a positive relationship between ASC and academic performance. This relationship was demonstrated during M1 and M2 year.

Based on evidence of the relationship between ASC and academic performance in the literature in K-12 (Möller et al., 2011; Seaton et al., 2014; Arens et al., 2017) and adult populations (Lent et al., 1997; Choi et al., 2005; Kornilova et al., 2009; Khalaila, 2015), it was expected that prior academic performance and ASC would inform subsequent performance. The results of the ordinal regression support prior findings around ASC and performance (Zhou et al., 2015). Zhou et al. (2015) found that prior performance and ASC informed subsequent ASC, which had an indirect impact on subsequent performance. However, the findings from Zhou et al. were specific to the first year of medical school, while the present study sought to explore the relationship beyond the first year to represent the entire preclinical phase of the curriculum.

Jackman et al. (2011) studied the impact of feedback on ASC among first-year medical students, but they did not find evidence of support for this relationship. The present study provided support for the relationship between academic performance and ASC in both the first and second year of medical school, which represents the preclinical phase at the study site. These findings add to our understanding of ASC among medical students and show that the relationship is not isolated to the first year of medical school. According to Marsh and Craven, a positive ASC is critical to maximize performance (2006). This assertion underscores the importance of a positive ASC for students as they progress through medical school. The analyses in the present study demonstrated support for a relationship between academic performance and ASC, though the models explored the impact of ASC on performance and did not explore the impact of performance on ASC. The models specifically explored prior performance and ASC as predictors of subsequent performance, though a Spearman's correlation analysis of MCAT scores, rank quartile, and ASC showed statistically significant relationships between ASC and performance both within and across timepoints. ASC at the end of M1 year (time 2) was correlated with academic performance at the end of M1 year, and ASC at the end of M2 year (time 3) was correlated with performance at the same time point. One interesting finding was the relationship between rank quartile at the end of M1 year and ASC at the end of M2 year, which suggested performance at the end of M1 year may impact subsequent ASC. One focus of the research was to explore factors that predicted academic performance, as measured by the likelihood of membership in a specific rank quartile. Correlations indicated an ongoing interplay between ASC and performance, which is aligned with a reciprocal effects model. The reciprocal effects model is the dominant model applied in most studies within the broader K-12 literature that focus on the relationship between ASC and academic performance (Marsh et al., 2005), where prior ASC informs subsequent performance, which informs subsequent ASC, and so on. Zhou et al. (2015) found evidence to suggest the model may apply to a medical education setting. Understanding the impact of ASC on academic performance, and of performance on ASC, would position educators to better assess learner behaviors and perceptions as they progress through the curriculum. Central to this model is the ongoing nature of the relationship between ASC and academic performance, rather than viewing the relationship as one-way, where ASC only informs academic performance, or where academic performance only impacts ASC.

Students' demographic characteristics were not significant in either model. These findings were somewhat unexpected, as prior literature has established differences in evaluations of students based on race and gender (Ross et al., 2017), as well as performance on standardized board examinations (Rubright et al., 2019). Race was operationalized in this study as URM or non-URM, which is more common in medical education, as opposed to broader aggregate racial categories that are more common in the broader K-12 and higher education literature. URM represented underrepresented minorities; specifically, racial and ethnic groups who have been historically marginalized or lacked access to medical school. Using this construct made it difficult to align with general studies of ASC within primary and secondary education contexts that explore aggregate racial categories. Beyond the operationalization of race, the proportion of URM students is much lower compared with non-URM students both in the study site and nationally. In 2019, only 7% of students matriculating in medical school were Black or African American, 6% were Hispanic, Latino, or of Spanish origin, less than 1% were Native Hawaiian or other Pacific Islander, and less than 1% were American Indian or Alaska Native (AAMC, 2019). These racial and ethnic categories comprise URM in the present study. Such uneven group sizes make detecting statistically meaningful differences difficult. Studies specific to ASC within medical education have not explored URM; further, because the literature within medical education is so varied in geographic and cultural context, it would be difficult to generalize findings to the present study.

There was an even distribution of students based on gender, with just over half of the study sample represented by female students. Gender was not a significant factor when looking at academic performance as an outcome in the present study, though other studies have explored gender differences in the performance of men and women within medical education (Ross et al., 2017; Rubright et al., 2019). Zhou et al. (2015) found that gender did not significantly impact pre-college ASC, so it was dropped from subsequent analyses in their study. Based on the results of the present study, it is difficult to determine what role, if any, gender plays in the relationship between ASC and academic performance in adult learner populations within the context of medical education.

While the study findings provide some evidence of a reciprocal relationship between ASC and academic performance, the study sample size limited the ability to conduct more complex analyses that would model a more detailed, reflexive relationship between ASC and academic performance. Multiple models were needed to explore primarily one-way relationships between ASC and academic performance.

ASC over time

The analysis of ASC over time across three cohorts indicated there was a significant change in ASC between matriculation and subsequent time points during medical school. ASC was highest at matriculation and declined by the end of M1 year. There weren't meaningful changes between ASC at the end of M1 year and the end of M2 year. These results provide useful insight, as there is limited literature on the longitudinal trends in ASC within medical education, particularly beyond the first year of medical school. A major change in ASC between the end of M1 and the end of M2 year would not be expected, as there were no major changes in the curriculum. Anecdotally, there are courses in both years that students may find more or less challenging. Where M1 year focuses on foundations of medicine, M2 year focuses on applied medical science. The domains are different, but the difficulty level varies across what is being taught. Many preclinical courses are didactic in nature. From a practical perspective, it makes sense that medical students would feel more confident in their abilities during matriculation into medical school. While students are aware of the curriculum and expectations for learning, it may be more abstract in nature compared with the reality of medical school, but this is just one possible explanation for the higher ASC prior to beginning courses. Matriculating students may not feel they can reliably compare themselves to their current peers, though social comparison may become more salient as students progress through the curriculum.

Abdalla et al. (2019) found that first-year students reported higher ASC than second-year students in their study of Malaysian medical students. This study was cross-sectional but demonstrated similar trends to the findings of the present study. In their study of Finnish medical students, Litmanen et al. (2014) found that there were differences in ASC between preclinical and clinical students; however, these results were only found for one type of curriculum, and there was not more specific evidence of change within or during the preclinical curriculum.

Studies have also provided some insight into ASC within the first year of medical school (Jackman et al., 2010; Zhou et al., 2015). Both studies explored changes in ASC in relation to other factors; specifically, academic performance. Zhou et al. (2015) found that pre-college ASC and academic performance directly and indirectly impact subsequent performance and ASC. These findings support a reciprocal effects model and provide evidence of the role of prior academic performance for ASC during matriculation. Jackman et al. (2010) did not find evidence to support the impact of feedback on ASC, but the qualitative phase of their study provided valuable insight into the role of peer comparison on developing ASC. These findings illustrate the importance of other factors beyond academic performance that may inform ASC, which are further explored in practical applications and implications for future research.

Practical application

There are practical applications for medical schools and educators based on the findings of the present study. Addressing any potential issues in the preclinical phase is essential for students' continued success in medical school. Medical school represents the first step on the path to becoming a practicing physician. In the clinical phase, students may pursue electives, and the structure of residency training varies by residency; however, in the preclinical phase, at least within the context of individual schools, students will overwhelmingly experience the same structured curriculum in the same amount of time. This makes the preclinical phase ideal for understanding experiences and identifying opportunities for improvement with the goal of helping students to advance in a positive way. The national attrition rates for medical students are relatively low, but medical students are at higher risk for burnout compared with general college populations, and they are likely to incur large amounts of debt. Add to that the competitive nature of residency programs, and students have the pressure to perform well academically to assure they are attractive candidates. If a positive ASC is necessary to maximize performance (Marsh & Craven, 2006), then ASC should be a construct of interest to educators to better position students for success in medical school.

The decline in ASC during the preclinical phase is an important finding. It suggests there is a change in how students perceive their academic abilities between the start of medical school and the end of their first year. The present study did not investigate how students form their self-concept in an academic context, but prior research has demonstrated the role of social comparison (Jackman et al., 2011) in particular among medical students. The study by Jackman et al. (2011) was the only study of ASC among medical students to use qualitative methods to explore the construct. Qualitative research in this space could provide insight into the processes and factors that inform ASC among medical students. The competitive nature of medical school is centered around whether a student is well-positioned for placement into a residency program compared with students both within and outside of their own institution. Preparing students for residency is a feature of medical schools, and beyond the curricular aspects of this preparation there are advisors, coaches, and other support mechanisms for students. These mechanisms provide students with a frame of reference for their performance. Academic coaching is a way for students to identify gaps in performance, set goals, and have a system of accountability (Deiorio et al., 2016). For a coaching relationship to be successful, coaches must have dedicated time for students and should not be in a supervisory role where they directly assess or evaluate the student's performance, and coaches need to have an understanding of medical education (Wolff et al., 2020). Because coaching employs an individualized, student-centered approach, it may give students a way to contextualize their performance with the guidance of a coach, which may help to inform their ASC beyond social or other comparison processes.

Implications for future study

There are several implications for future study based on the findings. These include opportunities to understand other factors that may relate to ASC, such as studies more specific to student characteristics or individual differences. Future studies may also expand beyond the preclinical phase into the clinical, or clerkship, phase of undergraduate medical education.

The purpose of this study was to understand ASC during the preclinical phase of medical school. Academic performance was a major factor in this study, as this relationship is underexplored within the medical education literature. There are other factors that may provide additional insight into the experiences of medical students, including aspects of the learning environment (Komarraju et al., 2010; Kim & Sax, 2014; Litmanen et al., 2014; Plecha, 2002), motivation (Kim & Sax, 2014; Komarraju et al., 2010; Plecha, 2002), and wellbeing (Maynor & Carbonara, 2012; Litmanen et al., 2014; Kaur et al., 2020). Litmanen at el. (2014) found that exhaustion and lack of interest partially mediated the relationship between ASC and the learning environment. In their study, the learning environment was operationalized as the type of curriculum, but the medical school learning environment may also be viewed as an ecosystem (Marshall, 1978) which includes learning experiences and interactions with students or faculty. The work of Litmanen et al. (2014) highlights the connection between wellbeing, the learning environment, and ASC among medical students. Like ASC in the present study, a decline in well-being during the first year of medical school has been documented across multiple studies (Michalec & Keyes, 2012). The preclinical phase of medical education occurs early in the medical students' academic and professional career. Understanding the various factors that may directly or indirectly impact students is important because these factors do not exist within a vacuum. There is evidence of the existing relationships between the learning environment and academic performance (Wayne et al., 2013) between the learning environment and wellbeing (Dyrbye et al., 2009), and between wellbeing and ASC (Maynor & Carbonara, 2012; Kaur et al., 2022). Taken separately, there is evidence within the literature of relationships between these various factors, and there is an opportunity to explore these factors more specifically within the context of ASC, as well as academic performance, for a more comprehensive understanding of the student experience and subsequent interventions or curricular changes to optimize those experiences.

Not only did ASC change over time, but there was also evidence of a positive relationship between ASC and subsequent academic performance. Future studies with larger sample sizes would provide the opportunity to explore the reciprocal effect model of the relationship. This model has been demonstrated outside of medical education (Möller et al., 2011; Seaton et al., 2014; Arens et al., 2017). Research that explores the relationship between performance and ASC as continuous and reciprocal, rather than a series of one-way analyses to determine impact of one factor on the other, would provide a deeper understanding of just how these factors work together. It would also help to identify timepoints that may be more critical for students where their ASC is concerned. Prior academic performance was the strongest predictor of subsequent academic performance in the ordinal regression models. Multi-site studies would also increase the generalizability of results to other medical schools within the US.

The relationship between ASC and academic performance provides an opportunity for educators and curriculum planners to better understand student experiences in the preclinical phase. The present study expanded on previous studies (Jackman et al., 2011; Zhou et al., 2015) that focused on ASC and academic performance among first-year medical students. While studies specific to ASC have included clinical-phase medical students (Litmanen et al., 2014; Yamada et al., 2014), there are opportunities to explore ASC longitudinally as students progress through the medical school curriculum. The clinical phase of UME may include didactic learning, but there are marked changes between the preclinical and clinical phases. The transition from the preclinical to the clinical phase can be stressful for medical students (Godefrooji & Diemers, 2010) as they go from theory to application to knowledge. Studying ASC across this transition would provide additional insight into students' beliefs about their academic abilities and identify opportunities to improve student outcomes. It is unknown whether ASC in the preclinical phase would be related to academic performance in the clinical phase, as performance is measured differently in the clinical phase compared with the preclinical phase. Future studies may also incorporate constructs related to ASC, such as academic self-efficacy, or even imposter syndrome. The integration of skills-based performance in the clinical phase in particular provides a strong opportunity to study self-efficacy. Artino Jr. at al. (2010) found medical students who were further along in the curriculum reported higher academic self-efficacy in patient care and evidence-based medicine compared with students in the earlier years of UME. While ASC and academic self-efficacy as constructs both rely on self-appraisal, self-efficacy is broadly considered to be more task-specific (Bong & Skaalvik, 2003), which may make it a particularly salient construct to understand in the clinical phase. Studying these related, but distinct constructs in combination with ASC would serve not only to better understand their respective roles in medical students' academic success, but also how each functions within the context of medical education. While Zhou et al. (2015) mentioned self-efficacy in their study of first-year medical students, there is a gap in the literature around the relationship between these two constructs and academic performance. The present study focused on specific factors within a set timeframe of medical education that ultimately represents a fraction of the overall medical training students will receive as they advance through their careers.

As discussed in practical applications, qualitative methodologies may provide additional insight into the experiences of medical students around ASC. Such methods could be particularly helpful to center the experiences of students who are underrepresented in medical school. Operationalization of demographic characteristics not only impacts the statistical inferences of quantitative studies, but it can also unintentionally marginalize or exclude individuals or groups, such as the use of a binary gender construct. While there are ways to operationalize demographic factors to be more inclusive using quantitative methods, qualitative approaches in particular could serve to center student experiences and further the goal of improving both experiences and outcomes while in medical school.

Limitations

There were several limitations associated with this study that impacted the generalizability of the results. These include limitations associated with the sample and with measurement.

Sample

Single-site study. While multiple cohorts and a longitudinal analysis increased both the overall sample size and opportunity to generalize results beyond a single cohort, there are limitations to a single-institution or single-site study. Because the study was conducted at one medical school, the results may not be generalizable to other schools within the US or medical schools outside of the US. There is variability in grading across medical schools, as well as variability in the demographic makeup of schools. While most medical schools implement a pass/fail approach to grading in the preclinical phase (AAMC, n.d.), tiered grading is more common during required clerkships. The overall impact of this aspect of the learning environment is unclear, and the ability to generalize across learning environments may be limited, depending on how similar or dissimilar the curriculum across medical schools.

Student populations and sample size. Sample size limited the ability to conduct a reciprocal effects model to explore the relationship between ASC and performance. The analyses used in the present study were appropriate for the research questions; however, larger sample sizes would have enabled more complex models to understand the longitudinal and reciprocal relationship between ASC and academic performance.

The sample was split between men and women, but the uneven distribution of URM students compared with non-URM students also limits the interpretability of findings for schools with more racially diverse populations and those that include larger URM populations.

Missing Data. Missing data in the present study presented a limitation. The end of M1 survey (time 2) had the highest percent of non-response data, and the end of M2 survey (time 3) had the second highest percent of non-response data. An assumption of data missing completely at random (MCAR) is that the missingness of data is not related to observable variables within the data (Little et al., 2012). Multiple imputation is an appropriate statistical method to handle data determined to be MCAR, but the overall missingness of the data remains a limitation of the study, as well as inferences made based on the analyses.

Measurement

ASC. The findings may be difficult to generalize to existing studies within medical education first because the literature is limited and second because of lack of consistency in the measurement of ASC in particular. No two studies within the literature use the same measure for the construct, though definitions are broadly aligned across the literature. The present study used the Academic Self-Concept scale (Liu et al., 2005) to measure ASC. A modified version of the ASCS was used in a study of Malaysian medical students (Abdalla et al., 2019), but the authors did not provide information about how the scale was modified or which items from the scale were used. The present study focused specifically on students in the preclinical phase, so more work should be done to understand the function of ASC within clinical phase students. Medical students must learn and subsequently apply their understanding of basic science and medical knowledge in both clinical and didactic settings. While ASC is widely accepted as both hierarchical and multidimensional (Shavelson et al., 1976), the instrument developed by Liu et al. (2005) was described by the authors as multidimensional, but not hierarchical. The items used in this study represented a confidence subscale from the original scale developed by Liu et al. (2005) and included an item modified to fit the context of medical education, which has demonstrated validity evidence (Stringer, 2018). This modified version of the scale to only include one dimension, while useful for interpretation around the confidence of students in their academic abilities, may remove other important dimensions of ASC that would inform the understanding of ASC among medical students.

Another factor that relates to measurement and interpretation of ASC within the context of this study is the timing of the administration. ASC at time point 1 represents matriculation, while ASC at the second time point represents the end of the first year. Students take their board examinations at the end of their second year, and surveys were typically administered during a time period when most students had already received their scores. Student ASC at this third time point may have been impacted by performance on Step 1. Students who performed well may have had more cause to feel confident in their academic abilities, while students who did not perform to their expectations may have been negatively impacted by this. It is unclear how the shift from a graded Step 1 exam to a pass/fail grading structure will impact students overall, but particularly with regards to perceptions about their academic abilities.

Student demographics. Measurement and operationalization of demographic factors, specifically gender and race, also present limitations. The variable representing gender in this study was operationalized as a binary construct. While this is common, and the application of a binary gender construct increases the generalizability of results from broader literature, only including male and female as possible categories, may not provide an accurate representation of a person's identity, and therefore inferences are limited. URM as a construct presents a similar limitation. URM does not represent an identity, but an aggregate construct representing groups of people with historical, systemic, and structural barriers to access of medical education. As a category, URM may provide valuable insight into student experiences, but it may not accurately capture the nuanced experiences of students based on racial or ethnic identity.

Conclusion

The purpose of this study was to understand the relationship between ASC and academic performance during the preclinical phase of medical school. The results of this study demonstrated a positive relationship between ASC and subsequent academic performance, as well as a decline in ASC during the preclinical phase. As medical students progress through their training, it is important to understand their early experiences. This understanding will hopefully inform and enable opportunities to improve student experiences and position students for success as they progress through their medical training on the path to becoming practicing physicians.

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