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Understanding and Evaluating Classroom Ecology

Amanda Kolpin
Bethel University

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AMANDA S. KOLPIN

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Amanda S. Kolpin

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Mary Lindell, PhD

Katie Bonawitz, EdD

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Abstract

Minnesota Rule 8719.5000 requires that special education teachers assess how environmental factors impact students during the evaluation process. Despite evidence explaining how environmental factors impact student achievement and behaviors, there is not a formal tool available to special education teachers that allows them to assess how classroom environment might influence a student. This project provides an extensive literature review examining how classroom ecology (the combined elements of the physical environment and social environment) impact student achievement. The literature review yielded twenty-two best practice indicators that informed the development of the Classroom Ecology Quality Indicator Tool. This tool will allow special education teachers and administrators to ensure evaluations are conducted with fidelity according to Minnesota law. The Classroom Ecology Quality Indicator Tool represents the first step in the researcher's effort to create a research-based, standardized method of evaluating classroom ecology.

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CHAPTER I: INTRODUCTION

I became a special education teacher several years after completing advanced degrees in human geography, a field many people would consider totally unrelated to special education. And yet, here I am, writing my thesis in special education on how classroom ecology impacts student learning and behavior – a topic very much connected to geography. I became interested in how the "geography" of classrooms impacts students after spending several years moving between different teaching spaces first as a paraprofessional, then as a substitute teacher, and then as a teacher-in-training. My early teaching experiences made me interested in how each teacher created his or her own classroom. Some rooms were brightly lit while others were aglow with soft light coming only from strands of Christmas lights and table lamps. Many teachers were highly organized, their classrooms divided into specific learning areas, libraries meticulously maintained, schedules easily visible and updated daily, processes in place for every student routine. Other teachers were less organized, their bookshelves overflowing with hastily stacked materials and books, schedules that were rarely updated, routines loosely enforced. Some rooms were heavily perfumed with "deodorizers" or essential oil, others were neutral. I have worked in a standard-sized classroom that was divided into five smaller spaces: two special education "rooms," a pull-out space shared by speech/language pathologist and occupational therapist, a sensory space, and an office area for school staff. I student taught in a building where the classrooms didn't have walls separating them from the hallway, exposing students to frequent din from passing classes and students in the media center. It struck me as interesting that teachers created such dramatically different learning spaces for students, but I did not realize just how important the classroom environment was in influencing student success.

I was not aware of the significance of classroom design, and had never even heard the term classroom ecology, until I came to Bethel. It was during my time at Bethel that I learned that classroom environment has been described as the "third educator" in the school setting (Gandini, 1998, p. 177). One of the licensure courses I completed, SPED 655 - Informal Assessment, was taught by Susan Schwope. Schwope introduced me to the idea of ecological assessment, which she described as a method of analyzing a student's "total learning environment." She provided the class with three tools we could use to assess classroom ecology during evaluations. Schwope described those tools as "conglomerations of material" she had collected over her career (personal communication, June 4, 2017). As I considered different topics for my thesis project, the topic of classroom ecology seemed like a good fit for my background and interests. I became especially interested in the topic as I considered the fact that classroom ecology was not often considered during the pre-referral and evaluation processes. Why is this of importance? Because in the state of Minnesota, statutes require that special education teachers assess the role of environment when evaluating students. Minnesota Rule 8710.5000 *Core Skills for Teachers of Special Education* subpart 2B requires that special education teachers critically consider the impact of environment on special education evaluation and programming.

Defining Classroom Ecology

Before delving further into this project, it is necessary to define and distinguish between the concepts of *environment* and *ecology*. "Learning environment" and "classroom environment" are terms that frequently pop up with respect to public schools, as is true with Minnesota Rule 8710.5000. Describing a learning space as an environment is appropriate; however, there is much to gain from describing it as an ecology. An environment is, quite simply, a defined area that

surrounds something. Ecology, while clearly connected to environment, attempts to "understand how individual organisms and populations interact with other species and, more generally, how organisms are linked to their biotic and abiotic environments" (Prudham, 2009). At a broad level, ecological studies examine the social interactions that take place between people and their environments (Kingsland, 2005). Classrooms are microsystems that are shaped by diverse and complex factors. These factors interact with each other to create what has been described as a "classroom ecology," a term rooted in Bronfenbrenner's (1979) work on ecological systems theory of child development that remains a theme of academic research today (Fisher, Godwin, & Seltman, 2014; Barrett, Zhang, & Barrett, 2011; Barrett & Zhang, 2012; Knight & Noyes, 1999; Barrett, Barrett, & Davies, 2013). A review of recent academic literature suggests there is a paucity of research focused on classroom ecology within the field of special education. This is interesting given widespread acknowledgement of the relationship between environment/ecology and human development and mandates for special education teachers to consider environment when assessing student needs.

> Maxwell and Schechtman (2012) describe Bronfenbrenner's model as focusing on: "the role of the individual's day-to-day experiences particularly in what are termed the proximal settings of home, school, and neighborhood. These settings play a critical role in development because they are the places where the individual most closely interacts with the environment and where important social relationships form with family, teachers, other adults, and peers. These relationships (with both the physical and social environments) serve as a context for development and it is through these reciprocal relationships that individuals obtain feedback about themselves" (p. 24).

More simply put, classroom ecology involves the study of how students and their teachers interact both with the classroom environment and with each other within that specific space. Classroom ecology can nurture or inhibit a child's development, both socially and cognitively/academically (for examples, see the work of Barrett et al., 2015b; Barrett et al., 2017; Fraser, 1998; Gandini, 1998; Guardino, 2012; Guardino & Fullerton, 2010; Hood-Smith & Leffingwell, 1983; Mendell, Eliseeva, Davies & Lobscheid, 2016; Schilling & Schwartz, 2004; Visser, 2001).

The paucity of academic research focused on ecological considerations in special education evaluations warrants investigation. Given widespread acknowledgement of the relationship between classroom environment and student success, it is important that we build understanding as to how social and physical components of learning spaces are taken into consideration by school staff during pre-referral interventions and comprehensive evaluations. The purpose of this research is two-fold. First, it reviews existing literature in a way that encourages academics, school administrators, and special education professionals to more seriously consider the importance of ecological assessment in the prereferral process and special education evaluations. Second, the information collected in the literature review was used to create a tool meant to help determine how classroom ecology might affect learning and behavior.

This project is divided into three sections. The first provides an overview of scholarly literature related to various aspects of classroom ecology. The literature review is divided into two parts, the physical components and the social components of classroom ecology. The literature review informs the second part of this project, the Classroom Ecology Quality Indicator Tool, which is meant to function as a tool school staff can use during the pre-referral and evaluation stages of the special education process when considering how a classroom's ecology

may impact a student's ability to be academically and socially successful. The final section of this project reflects on the literature review and the Classroom Ecology Quality Indicator Tool and provides recommendations for implementation as well as considerations for future research.

CHAPTER II: LITERATURE REVIEW

The categories covered within the Classroom Ecology Quality Indicator Tool reflect the range of diverse factors that comprise a classroom. Given the broad range of topics informing the quality indicator tool, but with consideration of the limitations of this research project, the literature review presented in this chapter focuses on research related to key terms including: environment, ecology, classroom, student, inclusion, integration, special education, evaluation, behavior, academics, disability, dyslexia, speech, autism, noise, density, organization, lighting, color, individualization, communication, and nature. The literature review also reflects the constantly evolving nature of classroom and special education teaching and the frequent, significant technological changes impacting learning in that it focuses almost exclusively on research produced in the last decade. The literature review has the depth and breadth to provide a context for understanding the factors that shape learning environments while also allowing the researcher to determine what might be considered best practice. Furthermore, it provides a foundation for possible future research focused on refining the proposed Classroom Ecology Quality Indicator Tool.

Few academics have written about classroom environment in a way that is accessible to the general teaching population. Guardino and Fullerton, however, did so in a 2010 article focused on how changes to the classroom environment can result in changes to student behavior. The duo cites a Public Agenda (2004) study that stated 75% of teachers believe they would be more effective teachers if disruptive behaviors were reduced in their classrooms (Guardino & Fullerton, 2010, p. 8). They also cited evidence showing that "modifying the classroom environment may serve as a direct intervention for children who demonstrate ongoing disruptive behavior" (Guardino & Fullerton, 2010, p. 9; Conroy, Davies, Fox, & Brown, 2002). And while

we know that classrooms which are intentionally and thoughtfully designed have "proven benefits," Guardino and Fullerston (2010) stated there is actually "little research on the impact environmental modifications have on behavior and learning" (p. 9). The researchers performed a micro study to test the impact modifications to the physical environment, such as rearranging furniture, increasing accessibility, and organizing materials, had on influencing behaviors in one fourth-grade classroom. Baseline data were collected during 15-minute periods of direct observation in the unmodified classroom to show the number of times disruptive behavior occurred that distracted from academic engagement during reading instruction. Collected data showed that students were engaged "less than 3%" of instructional time (Guardino & Fullerton, 2010, p. 12). Environmental modifications were put in place to determine impact. These changes included "seating arrangement; creating group space; adding organizational materials such as shelves, hooks, and labels; creating clear pathways in areas of high congestion; adding plants and inspirational posters; providing chair bags…and study carrels" (Guardino & Fullerton, 2010, p. 12). Four weeks of data were collected post-intervention and results determined that academic engagement levels increased and "stayed at or near 45%" and that disruptive behavior decreased from occurring "approximately 90% of the time" to occurring less frequently (the researchers noted that their data were "inconsistent during the final observations") (Guardino & Fullerton, 2010, p. 12).

Most research focused on topics related to classroom ecology is more academic in nature and focuses on physical elements. Of the existing research focused on the built environment and student success, one academic stands apart from the rest with respect to the breadth and significance of his work. Professor Emeritus Peter Barrett largely focused the early portion of his academic research on facilities design and management. Over the last decade, his focus has

shifted to researching the connection between the built environment of schools and students' academic success. Barrett, Zhang, Davies and Barrett (2015b), point out that prior to their research, studies connecting physical environment (or "internal environment quality") to student performance typically focused on a single "readily measurable" environmental factor such as heat, light, sound, and air quality (p. 6). What has been missing is research that combines the factors into a single study. Barrett and his colleagues accomplished just that – a study that examined the combined effect of different aspects of physical environment on student learning. This study is based on information collected from the Holistic Evidence and Design Project (HEAD) (Barrett et al., 2015b).

Prior to implementing their study, Barrett and his fellow researchers considered existing pertinent literature in order to determine which aspects of the school environment were "likely to impact on pupils' progress in learning" (2015b, p. 8). The authors wanted their study's sample to have "as much variety" as possible and included 27 schools from three areas in the United Kingdom: Blackpool, Hampshire, and the London Borough of Ealing (Barrett et al., 2015b, p. 10). School buildings ranged in age and were constructed beginning in the 1880s and into the 2000s. A total of 3,766 students participated in the study. The study focused on elementary school classrooms for two reasons: first, students typically spend the majority of their time in a single learning space, and second, there are academic standards in place, which makes it possible to gauge student progress. Students ranged in age from 5 to 11. Half were girls and half were boys (Barrett et al., 2015b, p. 13). Initial data related to physical environment focused on "hard measures" including, size of rooms, organization of learning spaces, desk placement, dimensions of windows, and location of doors and interactive whiteboards (Barrett, Davies, Zhang & Barrett, 2015a, p. 121). The team also analyzed other indicators they hypothesized might influence

student performance. These indicators focused on how much control occupants had over the classroom's environment, such as whether or not there were heating and cooling units in the room and if they could be individually controlled, if students had spaces designated for their belongings, the condition of learning materials, and both the complexity and color of decorations and displays (Barrett et al., 2015a, p. 121-122). Concrete measurements for lighting, temperature, humidity, CO_2, and noise were collected. This concrete data was not used to inform the study's metrics but to "provide an enhanced opportunity for the researchers to identify potential problem areas" (Barrett et al., 2015a, p. 122). The final component of the study's method included an interview that followed a questionnaire. This tool collected qualitative information related to how each teacher experienced his or her classroom. Data collected through the interviews yielded information that the researchers took into consideration but did not use to inform the study's metrics or results (Barrett et al., 2015a, p. 122).

Each of the aforementioned factors' influence on learning was individually considered through bivariate analysis. This process included refining the resulting data, which was then put through "a multi-level analysis" to determine their "combined effects" (Barrett et al., 2015a, p. 124). A "multi-level model" was used to study the impact of environment on students' overall progress; this statistical examination was conducted using specialized software (Barrett et al., 2015a, p. 125). Each factor was individually tested using a factor-specific model. A "top-down approach" was used to incorporate each factor into the model in order to show the "combined effect" of the factors and then each factor was removed to determine its "individual significance in the overall model" (Barrett et al., 2015a, p. 125). Barrett and his colleagues retained factors that "significantly improved" their model; if the factor's impact was considered inconsequential it was not included. After the factors were sifted through the modelling process, those that had

been excluded were reincorporated because they were considered to ultimately impact the other factors (Barrett et al., 2015a, p. 125). The team used scatterplots to determine the relationship between pupil progress and each isolated factor (Barrett et al., 2015a, p. 126). The modelling process showed that all ten factors – light, sound, temperature, air quality, links to nature, ownership, flexibility, connection, complexity, and color – were "positively correlated with progress." Of these factors, light had the most powerful correlation with progress, and the combined impact of light, temperature and air quality "explained 49% of the effect on the overall progress model." Ownership and flexibility accounted for 28% of the effect, and color and complexity accounted for 23% of the overall progress model (Barrett et al., 2015a, p. 127).

Ultimately, the team determined that "the impact of the physical space occupied is indeed an holistic experience in which a full range of factors are in play" (Barrett et al., 2015b, p. 15). Importantly, evidence suggested that school-level factors were not of enough "sufficient importance" to be included in as main factors influencing student progress; in fact, Barrett et al. (2015b) state the "overwhelming focus should be at the classroom level" (p. 15). As a result of the team's HEAD Project research, Barrett and his team determined there is "clear evidence of the effect on users of the overall design of the physical learning space" and that it can explain "16% of the variation in the overall progress" during one academic year of the students in the study (2015b, p. 14). This single statistic should be enough to make educators seriously consider how classroom ecology impacts learning and behavior.

The model used to organize the HEAD Project was based on the earlier work of Barrett and Barrett (2010). This duo concluded there are three main factors that directly shape student performance. The first factor is *naturalness,* or the level to which students are exposed to elements of nature within the classroom setting. The second factor is *individualization*, which is

focused on students' location within the classroom setting, their sense of ownership, and their relationships to the other students and adults in that room. The final factor is *stimulation*, which is focused on the visual complexity of the classroom (Barrett & Barrett, 2010). It is interesting that Barrett and his colleagues for his various publications consistently refer to the significance of the physical environment, yet his model does include individualization, which is very much based on social elements of the classroom. This points to the importance of considering a classroom's ecology when evaluating its impact on student learning. With this said, Barrett's model and research significantly informed the research presented in this literature review and the tool for evaluating the health of a classroom's ecology.

As has previously been pointed out, existing research connecting environment to learning is usually focused on a single factor, such as air quality or visual stimulation. The literature review presented over the following pages summarizes existing research for several of these individual factors into one place. It is divided into two major themes: physical components and social components of classroom ecology. With consideration to the physical components of a classroom's ecology, the literature review considers visual stimuli, noise, lighting, temperature and air quality, natural elements, and accessibility. With respect to the social components of a classroom's ecology, this literature review focuses on classroom density, communication, scheduling, opportunities for choice, student integration, and individualized instruction.[1]

[1] It should be noted that researchers provide different definitions for physical characteristics and social characteristics of classroom ecology. Odom, et al. (2001) suggest that physical characteristics might include the activities, routines, and schedules, and classroom density (p. 27). These are characteristics that I would consider social in nature because they are actively and intentionally constructed by humans and give shape to social activities.

Physical Components of Classroom Ecology

Visual Stimulation

A growing body of research considers the effect of visual stimulation on students' ability to attend to task and their resulting levels of achievement. Godwin and Fisher examined this topic in a 2011 study and revisited the topic again in 2014 (Fisher, Godwin & Seltman). Fisher et al. (2014) examined 24 kindergarten students' ability to attend to science lesson content when they were exposed to different amounts of visual stimulation. Students were divided into two equally sized groups; each group had six boys and six girls. Over a two-week period, a researcher who was trained in early childhood education instructed both groups of children on topics ranging from plate tectonics to bugs (Fisher et al., 2014, p. 1364). The researcher-teacher was unaware of the of the team's hypotheses. The researcher-teacher provided reading instruction in a classroom that had minimal visual stimulation ("low visual distraction") one day and was visually "busy" and decorated ("high visual distraction") the next. Each group of students participated in a total of six lessons over a two-week period.

Results from the study suggested that students showed decreased ability to attend and had limited gains in learning when lessons were provided in the visually stimulating classroom. Students were "more likely to be distracted by themselves or by peers" in the highly decorated classroom (Fisher et al., 2014, p. 1367). In fact, over 85% of the study's sample population "spent significantly more instructional time" engaged in off-task behaviors when placed in classrooms with considerable visual stimulation (Fisher et al., 2014, p. 1367). Researchers also stated that students in the sparsely decorated classroom spent approximately 3.21% of instructional time distracted by the surrounding environment. Students in the highly decorated

classroom were found to be off task 20.56% of the time (Fisher et al., 2014, p. 1366).[2] The more time a student spent not attending to task resulted in reduced achievement levels (Fisher et al., 2014, p. 1367). While students "successfully learned" in both settings, students' "gain scores" (the difference between pretest and posttest scores) were greater in the learning spaces that had minimal visual distraction (Fisher et al., 2014, p. 1366). In the sparsely decorated classroom, students average score raised from 22% accuracy on the pretest to 55% accuracy on the posttest. In the highly decorated classroom, students' mean score on the pretest was 23% accurate; students had a mean score of 42% accuracy on the posttest (Fisher et al., 2014, p. 1366). The researchers concluded that "classroom type affected the children's attention allocation (they spent more time off task when the classroom was highly decorated than when it was not decorated), and time off task reduced learning of the lesson content" (Fisher et al., 2014, p. 1367).

Rodrigues and Pandeirada (2018) experimented with visual stimulation by examining the performance of 64 students ranging in age from 8 to 12 years old in a setting in which distractors were present or not present in the surrounding environment. The researchers argued that studies typically focus on distractors that are present in a single display, such as a computer monitor. Rodrigues and Pandeirada sought to broaden understanding of visual distractors by considering the classroom setting. Students were evaluated in four sessions – two sessions each in a "low-load" environment and a "high-load" visual environment. The low-load environment was comprised of a white three-part divider that blocked the child's peripheral and front views and had no additional visual elements. The high-load environment utilized the same type of white

[2] It should be noted that Fisher et al. (2014) pointed out that while students were significantly more distracted by environmental considerations in the decorated-classroom, the percentage of time spent off-task due to being distracted by other peers was higher in the sparsely decorated classroom (approximately 20%) than the heavily decorated classroom (approximately 15%) (p.1366).

divider but had 24 unrelated small posters plastered on its three faces (Rodrigues & Pandeirada, 2018, pp. 144-145). Participants completed four "visuospatial cognitive tasks," two focused on attention and two on memory (Rodrigues & Pandeirada, 2018, p. 144). These tasks were performed in both of the previously described settings. Results from the duo's study showed that cognitive performance for all four task areas was lower in the high-load visual environment. Students in the low-load environment also had faster reaction times and fewer incorrect answers (Rodrigues & Pandeirada, 2018, p. 146). When discussing the results of their work, Rodrigues and Pandeirada (2018) also noted an important fact that teachers should take into consideration with respect to visual stimulation: "children's cognitive capacities are still under development, including executive functions responsible for the filtering of irrelevant information for a given task" (p. 147).

The research of Hanley, Khairat, Taylor, Wilson, Cole-Fletcher and Riby (2017) looked at visual stimulation and academic performance of students with and without autism. The study's authors used eye-tracking techniques to examine how visual stimulation influences attention and learning of students. Results were collected for 34 participants (17 children with autism and 17 children considered typically developing) over three separate sessions. The first session measured cognitive ability. In the second session, students watched videos of two story-times and completed a set of eye-tracking tests. In the third session, students watched videos of two mini-lessons. In both the second and third sessions, one video lesson or story-time was presented using a highly stimulating background screen (high visual display, or HVD) and the other video lesson or story-time was presented in a no-display background screen (no visual display, or NVD). During the lessons, researchers tracked students' eye motions to monitor their ability to attend to task and assessed their ability to learn in the different settings using worksheets after

each lesson. Results showed that during the high visual story-times, displays significantly influenced attention for *all* students; regardless of lesson type, eye-tracking software allowed researchers to determine that learners "spent more time looking at the background in HVD compared with NVD" (Hanley et al., 2017, p. 1272). Students with autism were the most significantly impacted (Hanley et al., 2017, p. 1272). Students also received lower learning scores on the high visual display lesson. The researchers considered various predictors for student learning (age, attention abilities, verbal, nonverbal), but determined the visual stimuli in the high visual display lessons was the overall most significant predictor of success. Regardless of whether the child had or did not have autism, the factor that had the most impact on the regression model was the amount of time children spent looking at the high visual display background (Hanley et al., 2017, p. 1273).

Other research on visual stimulation has focused on the relationship between color and student performance. In their 2012 study of how color can impact student performance, Jalil, Yubusb, and Said summarized research from 40 separate studies focused on the negative effects of certain colors. The literature included in their analysis was written between 1964 and 2011 and focused on four categories of variables: "emotion assessment," "performance or non-performance," "physiological assessment," and "actual or/and made up scenario and context" (Jalil et al., 2012, p. 57). The studies were based on data collected in a range of different environments – laboratories, workspaces, hospitals, and a number of studies conducted at individual sites. Nine of the studies were focused on educational settings. From their review, the trio offered several pieces of information that are pertinent to understanding the role of color in learning environments. They described the effect of red as linked to "avoidance behavior," blues as having a "sleepy effect," and greens having a "calming effect" (p. 58). One of the most

significant takeaways from their summary was related to the use of the color white. White is often considered a "natural colour [sic]," but certain testers made more performance errors in that environment (Jalil et al., 2012, p. 59).

Stern-Ellran, Zilcha-Mano, Sebba and Binnun (2016) considered the role of colorful surfaces on behavior. They argued that "sensory enrichment" is often provided through the incorporation of "colorful play areas" in early childhood learning spaces, but that there is minimal evidence pertaining to the effects of those environments on children. Researchers had preschoolers play three separate games. Games were played on a surface covered in paper that was "busy" with colors and images *or* white paper. Evidence from the research suggested that children were more likely to demonstrate disruptive behaviors when their game was played on the colorful surface, and that those behaviors interfered with their ability to attend to a task. Stern-Ellrean and her colleagues observed that when children participated in activities on colorful surfaces, they were observed to be "bringing their heads closer to the working surface, staring away, emitting vocalizations and statements indicating frustration or feeling of incompetency…and making more use of manual, rather than visual search" (2016, p. 7). The authors also clearly stated while their study could not identify the specific "mechanisms" that affect "attentional, perceptual, or other cognitive processes," they do believe that "excess of hue and brightness" of colorful surfaces require substantial "mental resources" that ultimately detract from the amount of resources children have available for "normative play," and that this can lead to "tiredness, fatigue, and difficulty in task execution" (Stern-Ellran et al., 2016, p. 8).

Barrett et al. (2015b) provided specific parameters for visual stimuli in their *Clever Classrooms* report. In it, they recommended that visual displays should "provide a lively sense to the classroom," but that teachers should avoid creating displays that feel "chaotic" (Barrett et al.,

2015b, p.35). A classroom appropriately decorated with displays should have between 20%-50% of wall space kept clear of any materials (Barrett et al., 2015b, p. 35). The also argue research points to the importance of displays being set against a "calm backdrop" (Barrett et al., 2015b, p. 36). Students best responded to visual stimuli when the room had lightly colored walls with a single wall painted a different color (Barrett et al., 2015b, p. 36).

Sound

Barrett et al.'s (2015b) summary statement on the role of sound in influencing learning environments divides noise into two categories: internal and external. Internal noises are those that occur through foot traffic, moving chairs, and student conversation. External noises are those that take place outside of the classroom, such as playground conversations and traffic. The team discovered through their research that while noise does impact learning and social development (as is evidenced in Crandell & Smaldio, 2000; Picard and Bradley, 2001), it was "competed out in importance by other factors" (Barrett et al., 2015b, p. 24). However, they also note that for special education students, it is still important to account for sound as they are more likely to be impacted.

The influence of sound on students' performance becomes more significant when we consider that students spend between 45% and 75% of their school day trying to listen to and process spoken language (Rosenberg, Blake-Rahter, Heavner, Allen, Redmond, Phillips & Stigers, 1999). Puglisi, Astolfi, Cantor Cutiva, and Carullo (2015) examined this issue. The team's research focused on an Italian elementary school located near "low traffic arteries" (Puglisi et al., 2015, p. 716). Acoustical measurements were focused on four teachers who taught in three classrooms. Data was collected at two points. The first measurement was taken prior to a "low-cost and light project to enhance the acoustical quality" of the classrooms and the second

was taken after the renovation (Puglisi et al., 2015, p. 716). Renovations targeted noise and reverberation. Results from their study suggested that reverberation and noise can increase vocal strain while reducing speech intelligibility, which consequently impacts overall learning. The team also pointed to research showing "acoustic discomfort" for teachers and students resulting from ambient noises and reverberation can consequently cause nervousness, headaches, and reduced concentration - all of which can negatively impact how content is taught and learned (Puglisi et al., 2015, p. 715).

In classrooms with significant ambient noise, students who struggle with hearing and/or processing language must work extra hard to discriminate noise. This is also true for students with autism. When students with autism are exposed to stimulus noise they are likely to seek sensory input, which can have the consequence of limiting attention and concentration (Kanakri, Shepley, Tassinary Varni, & Fawaz 2017, p. 88). In Kanakri et al's (2017) study, the team collected observational data in four classrooms (two classrooms each at two schools). The classrooms were designated as quiet or noisy using noise decibel guidelines established by the World Health Organization and the American National Standards Institute (Kanakri et al., 2017). Baseline data were collected for 15-minute periods in unoccupied classrooms. A total of 42 students (20 at one school and 22 at the other) with medical diagnoses of high functioning autism were included in the study. The researchers based their data collection on five behaviors they identified through a review of existing literature focused on the relationship between noise and behavior in students with autism (Kalakri et al., 2017, p. 859). Seven behaviors were tracked, including stereotypy, repetitive speech, ear covering, hitting, loud vocalizations, blinking, and complaining. These behaviors were monitored using a video camera attached to a decibel meter. At the end of the 6-week observation period, 64 hours of data were collected for each classroom

(Kalakri et al., 2017, p. 860). Results showed there was a "significant positive correlation between decibel level and complaining, repetitive speech, hitting, producing loud sounds, and repetitive motor movement" (Kalakri et al., 2017, p. 861). Thus, while stimulus noise may not be of great significance for a classroom's "average" student, research indicates that a noisy environment is critical to consider when assessing the needs of students with disabilities.

Oliveras-Ortiz (2017) examined the impact of school design on school engagement. As part of her study, she considered the impact of sound on engagement; she argues that classroom sounds can significantly inhibit teaching and learning. Her research focused on students and teachers who had attended or taught at both a brand-new school and the building that proceeded it. Oliveras-Ortiz did not indicate the total number of students who participated in the study; however, 64 teachers who taught in both in the old building and the replacement campus were included in the teacher sample (2017, p 13). Students, who were aged 10-11, participated in focus group sessions that followed a standardized list of questions. Their answers were later analyzed for common themes. Teachers completed anonymous surveys that were also analyzed. Results from the focus groups and surveys were then reviewed to determine how the new school environment influenced both student and teacher engagement levels (Oliveras-Ortiz, 2017, pp. 11-12). As part of the new building's design, spaces were designed in order to improve the overall sound quality. Results from the student focus groups revealed they found that sounds were "'much quieter'" (Oliveras-Ortiz, 2017, p. 28). Oliveras-Ortiz refers to the work of Smaldino and writes, "classroom noise, inside or out, at deleterious levels can hinder speech perception but also reading scores, spelling ability, behavior, attention and concentration" (p.9; Smaldino, 2008). Classrooms located in urban settings are more likely to be "bombarded with ambient noise" which further complicates children's abilities to not only hear but attend to task

and process information (Oliveras-Ortiz, 2017, p. 9). Oliveras-Ortiz also suggests that traditional classrooms are not equipped with the acoustics necessary to ensure that when students are spread out across the room, they can hear what a speaker is saying. She states that "deliverance of speech energy" is limited to the "front most rows" and that the "spread of signals" to other parts of the room is limited (Oliveras-Ortiz, 2017, p.9).

Lighting

Abundant research points to the role of natural light in promoting overall student well-being and achievement. Full-spectrum light is considered critical to the healthy development of a child. Knowing this, researchers have argued that "to help reduce the imbalances caused by inadequate exposure to the near ultra-violet and infrared ends of the spectrum, full-spectrum bulbs that approximate the wavelengths provided by sunshine should replace standard fluorescent and tungsten bulbs" (Tanner, 2008, p. 385). Substandard lighting can cause some students to act as though they had "jet lag." More serious cases can cause a classroom's occupants to experience mild seizures (Tanner & Lackney, 2006, p. 270). Tanner (2008) cites evidence from existing research (e.g. Heschong Mahone Group, 1999) indicating that classrooms with the most daylight had students that "progressed 20 percent faster on mathematics and 26% faster on reading tests over a period of one year than students having less daylight in their classrooms" (p. 385). Tanner also suggests that one way of ensuring students benefit from maximum natural light is to position windows on south-facing walls (Tanner, 2008, p. 385).

Van Mil, Briere, Jeong, Popovic Larsen and Pind (2018) argue that "focused, local light leads to high-spatial contrast that constructs an atmosphere that promotes pupil behavior and mood states benefitting their ability to concentrate" (p. 1768). The authors' hypothesis was rooted in observations that teachers often alter learning spaces "by using local light sources

instead of the generic ceiling lighting to promote focus and concentration" (Van Mil et al., 2018, p. 1768). To test the impact of focused, local lighting, the research team considered the level of noise during focused learning activities that look place in situations with different types of lighting.

The researchers included four learning spaces located within a new public school in Denmark. Two of the spaces were shared by students in 1st through 3rd grade and the remaining two spaces were used by students in 4th through 6th grades. The younger grades used their shared spaces for a range of activities. The older grades used their spaces for mathematics instruction (Van Mil et al., 2018, p. 1768). The specific number of students included in the study was not identified. The spaces had two lighting options: default and prototype. The default design included "six evenly spread ceiling luminaries," which produced a "low-contrast distribution of light" (Van Mil et al., 2018, p. 1768). The prototype design added six focused lighting pendants located above work areas (Van Mil et al., 2018, p. 1768). Teachers could use both lighting options or the prototype lighting option to illuminate the room. Researchers measured noise levels, physical activity during instruction, and students' feelings toward learning spaces. Students' classroom work was assessed to determine ability to attend to "focused-based learning activities" (Van Mil et al., 2018, p. 1769). Researchers installed a sound meter to monitor noise level throughout the school day and video clips were analyzed to compare noise levels (Van Mil et al., 2018, p. 1769).

The researchers described the "luminous atmosphere" created by the uniform artificial lighting (the default lighting option) typically found in schools as "uninspiring and dull," and suggested that when teachers alter classroom lighting, they "effectively change the manifestation of spatial contrast in their environment" (Van Mil et al., 2018, p. 1768). Results showed that in

70% of cases noise levels were lowered when classrooms incorporate focused, local light, "which potentially implies that the students can focus on the class better, and accordingly students learning could be higher [*sic*]" (van Mil et al., 2018, p. 1769). This suggests that when teachers incorporate the use of localized light sources (pendant lights, table lights, etc.) instead of exclusively standard overhead lighting, they change the learning environment in ways that allow students to better focus and concentrate, and that this may yield improved learning.

Air Quality

Wargocki and Wyon's research (2007a) indicates students' learning improves when instruction takes place in cooler environments. The duo's study included two field experiments focused on students in their real classrooms while performing regular learning tasks. The air temperature was intentionally altered in two separate classrooms; each classroom had a different temperature one week and the temperatures were switched the following week (Wargocki & Wyon (2007a, p. 195). Within the study's methodology, the authors explained they included evidence from a separate research paper (2007b) in which the rate of outdoor air supply and filter conditions were altered. In the first experiment, "each air temperature was re-imposed but with a different outdoor air supply rate" (Wargocki & Wyon, 2007a, p. 195). In the second experiment, "the air temperature was changed but the outdoor air supply rate remained constant" (Wargocki & Wyon, 2007a, p. 195). The experiments took place in successive school years. Participants still had the option of opening windows and doors as needed and no changes were made to any school activities in order to maintain a level of normalcy. Students were unaware of their participation in order to collect accurate data related to the changed environmental factors (Wargocki & Wyon, 2007a, p. 196).

The duo's study showed that by reducing the temperature from 77 degrees Fahrenheit to 68 degrees Fahrenheit, students demonstrated improved speed performance on mathematical and literacy tasks (Wargocki & Wyon, 2007a, p. 194). Additionally, evidence showed decreased calculation errors and a reduction in the severity of headaches, which the researchers interpreted to mean the tasks were easier to perform (Wargocki & Wyon, 2007a, p. 215). Elsewhere, in research supporting the work of Wargocki and Wyon, Barrett et al. (2015b) have argued the most effective way for teachers to control temperature is to place a thermostat in each classroom. Recommended classroom temperatures range from 68-75 degrees Fahrenheit in the winter and 72-79 degrees Fahrenheit in the summer (Haverinen-Shaughnessy & Shaughnessy, 2015, p. 2).

Ventilation has been at the core of several studies focused on the impact of poor indoor air quality on student performance, with much of the evidence suggesting that poor ventilation rates are linked to reduced testing performance (Bako-Biro, Clements, Croome, Kochhar, Awbi, & Williams, 2012; Mendell, 2016; Petersen, Jensen, Pedersen, & Rasmussen, 2016; Twardella, Matzen, Lahrz, Burghardt, Spegel, Hendrowarsito, Frenzel & Fromme, 2012). Indoor pollutants that affect indoor air quality are emitted from the buildings themselves, as well as the people, cleaning products, and objects located within their walls. These pollutants may go largely unnoticed but contribute to an overall poor level of air quality. Evidence suggests exposure to poor indoor air quality contributes to "illness, absence, acute symptoms, and impaired cognition or performance" (Mendell, Eliseeva, Davies & Lobscheid, 2016, p. 546). Mendell et al. (2016), citing the work of Haverinen-Shaughnessy et al. (2011), suggest that "lower ventilation rates during a school year were associated with reduced academic achievement as measured by standardized annual tests" (p. 547). One way of measuring a classroom's ventilation rate is to measure the amount of carbon dioxide in the space. While CO_2 is not itself a pollutant, the

amount of CO_2 in a classroom is "recognized as an indicator of ventilation rates" (Barrett, 2015b, p. 21). Thus, if a CO_2 meter shows heightened levels of the invisible gas, it should signal to staff that students may benefit from exposure to fresh air. If possible, corrections, such as opening a window, should also be made to modify the classroom environment.

Natural Elements

One indicator of "naturalness" is students' accessibility to nature from within the classroom. Benfield, Rainbolt, Bell and Donovan (2015), explain that connecting humans to natural environments, even if only as the view outside a window, can "restore cognitive abilities and reduce physiological arousal" (p. 140). Yet, school buildings, and especially individual classrooms, remain largely blocked off from the natural world. Edwards and Torcellini (2002) provided an extensive review of literature focused on the impact of natural light on humans who occupy various building types, including schools.[3] They point out that windowless classrooms are common. Less window space in classrooms equates to fewer opportunities for distraction, reduced noise, and lower energy costs. Likewise, dedicating less space to windows means increased wall area or decorations and storage (Edwards & Torcellini, 2002).

Benfield et al.'s (2015) examination of students learning in classrooms with views of nature and classrooms with obstructed views showed that rooms with "visual access to a natural environment promoted positive classroom outcomes" (p. 149). The study focused on 567 college students. Nine of the classes met in rooms that had windows that looked out at a concrete wall. The other 29 classrooms looked at a "grassy area containing blossoming trees" (Benfield, 2015, p. 145). Students completed a single page questionnaire in which they were asked to rate the

[3] Edwards and Torcellini's literature review (2002) does not specific the number of studies analyzed within their research. The author of this project counted 93 articles cited in the article's "References and Bibliography" section (pp. 39-45).

course using a five-point scale. Questions covered curriculum, quality of materials, instructor, physical aspects of the building, and resources (Benfield, 2015, p. 145). The study also considered objective measurements of student grades and attendance. Data from the study indicated that views of nature could factor into "lowering student stress, restoring student attention, and/or enhancing the overall mood, which translates into a better classroom experience…lower stress and enhanced mood could also account for the higher overall course grade" (Benfield et al., 2015, p. 153). The authors' work focuses on college students' experiences; however, given the volume of research connecting human productivity and well-being with views of nature, it is reasonable to suggest their findings can be extended to students in K-12 settings.

Tanner (2009) identified how classrooms' windows should be taken into consideration during the building process. He describes light as the "most environmental input, after food and water, in controlling bodily functions" (p. 385). In fact, if classrooms are poorly lit, its occupants can "experience a daily form of jet lag" (Tanner, 2009, p. 385) and medical researchers have argued that classrooms without windows should be "avoided for permanent use" (p. 386). Evidence suggests that classrooms with windows are not only better from a health perspective, but also from an academic perspective. Tanner (2009) referenced data from a study of over 21,000 students (Hechong Mahone Group, 1999) that determined students who were exposed to the "most day lighting in their classrooms progressed 20 percent faster on mathematics and 26 percent faster on reading tests over a period of one year than students having less daylighting in

their classrooms" (Tanner, 2009, p. 385).[4] Elsewhere, Tanner and a colleague identified ideal "patterns of view" (Tanner & Lackney, 2006). The first is that views should overlook life – students should not gaze upon a wall or a paved lot. Views should be unrestricted. Every classroom should have a window, and the window should not be covered. Students should have living views of wildlife, the natural landscape, the sky, and gardens. When students peer out of doors or windows, their eyes should be met with functional views that allow them to see a minimum of 50 feet beyond their location. This ensures students can "rest their eyes" between tasks (Tanner, 2006, p. 386).

Social Components of Classroom Ecology

Social Interaction

It is well-known that when students perceive their teachers to be supportive and invested in their well-being, they are themselves more invested in their schoolwork (Rex, Steadman & Graciano, 2006; Ciric & Javanovic, 2016). When teachers have low expectations for students, they "ask easier questions, allow less time to respond, and provide less encouragement for engagement of students" (Ciric & Javanovic, 2016, p. 190). Likewise, when students like each other, it is more likely they will feel "secure and accepted, which in turn positively affects academic adjustment" (Hendrickx, Mainhard, Boor-Klip, Cillessen & Brekelmans, 2016, p. 31; Roseth. Johnson & Johnson, 2008; Wentzel & Caldwell, 1997) and implies less negative behaviors (Hendrickx et al., 2016, p. 31).

[4] The Hechong Mahone Group study, titled "Daylighting in Schools," reviewed test results for 21,000 pupils from three school districts located in various parts of the United States (Orange County, California, Seattle, Washington, and Fort Collins, Colorado). In order to collect their data, the researchers "reviewed architectural plans, aerial photographs and maintenance records and visited a sample of the schools in each district to classify the daylighting conditions" in more than 2000 classrooms (1999, p. 2). Classrooms were assigned values (on a 0-5 scale) based on the size and tine of windows and the amount of expected daylight. Multivariate linear regression models were used to analyze environmental and student performance data.

Teachers are the primary agent responsible for the social interactions that occur in classrooms. Abundant research shows that "academic engagement, social competence, and emotional adaptation are associated … with the level of warmth and emotional sensitivity that teachers demonstrate with the class" (Hendrickx et al, 2016, p. 248; Buyse, Verschueren, Verachterrt & van Damme, 2009; Curby, LoCasale-Crouch, Konold, Pianta, Howes & Burchinal, 2009; O'Connor, 2010). Hendrickx et al's study (2016) included both teachers (n=58) and fifth grade students from 58 classrooms (n=1454) (p. 33). Quantitatively measuring social dynamics such as those that exist in classrooms is tricky. The research team accomplished this by having students and teachers complete a measurement tool called the Questionnaire on Teacher Interaction for Primary Education. This 16-item tool is focused on assessing "teacher support and conflict" along a continuum (Hendrickx, 2016, p. 34). Respondents used a five-point Likert scale to rate their opinions; students answered questions about their specific teacher (identified in the questionnaire by name) and teachers' responses focused on how they considered their teaching within that classroom (Hendrickx, 2016, p. 34). The research team also used video observations to assess and measure support and conflict from an objective perspective and "coded all dyadic teacher-student interactions for the amount of support and conflict" that was demonstrated by the teacher (Hendrickx, 2016, p. 34). Their study suggested:

> When teachers generally show support and have positive interactions, the modeling perspective assumes that students are more likely to emulate this behavior, that is, to show warmth to each other and engage in positive interactions with peers as well. Likewise, teachers who generally show much conflict and negative affect may stimulate conflicted contact among students as well" (Hendrickx, 2016, p. 32).

When teachers target specific students with negative comments, they "inform the classroom group on their differential value" (Hendrix, 2016, p.32). The overall results of the study indicate that that when teachers demonstrated negative interactions with students, it "paved the way" for negative behaviors amongst students (Hendrickx et al., 2016, p. 37).

Several studies provide evidence of the correlation between negative teacher-student interactions and problematic behavior, and that teacher-student conflict may result in increased aggressive behavior if left unmediated over the course of the school year (Doumen Verschueren, Buyse, Germeijs, Luyckx & Soenens, 2008; Doumen, Verschueren & Buyse, 2009; Murray-Harvey & Slee, 2010). Farmer, Lines, and Hamm (2011) summarize the aforementioned research by stating they show "students with behavior problems are likely to establish conflictual relationships with teachers which in turn may support students' sustained patterns of social and emotional adjustment problems" (p. 248). Consequently, if a student demonstrates antisocial or aggressive behaviors and his or her classroom teacher is considered to demonstrate disproportionate negative behaviors or interactions with students, it may be beneficial to assess how the teacher interacts with students and then propose interventions that yield prosocial, supportive relationships.

Reinke and Herman (2016) developed a tool that is specifically meant to document how teachers interact with students. The Brief Student-Teacher Classroom Instruction Observation is an objective five-minute "snapshot of the amount of praise versus reprimand a student receives from a teacher within a very short time frame" (Reinke & Herman, 2016, p. 43). Teacher responses are tallied for "behavior specific praise, general praise, explicit reprimands, and harsh reprimands" (p. 43). During the same time period, the observer tallies the incidences of disruptive and aggressive behavior displayed by the student. The data collector than calculates

the number of positive and negative interactions and subtracts the reprimands from the praise. Results from a study conducted to test the Student-Teacher Classroom Instruction Observation tool indicates it is valid and has the potential to reshape instructional practices (Reinke & Herman, 2016). The tool may be especially useful for helping teachers build awareness of the fact they may be "interacting more negatively with particular students" (Reinke & Herman, 2016, p. 45).

Classroom Density

Considerable research is dedicated to examining the benefits of small class sizes on students (Glass, Cahen, Smith & Filby, 1982; Ehrenberg, Brewer, Gamoran, & Willms, 2001). As a result of this research, we know that children in smaller classes are likely to outperform peers on achievement tests. Maxwell's research (2003) shifted the focus away from the number of pupils in a classroom to classroom density, or square footage per student. In her study, Maxwell assessed 73 second- and fourth-grade students (at two separate elementary schools) using the *Woodcock Reading Mastery Tests-Revised* (1987) to gauge their performance on word identification and word attack (Maxwell, 2003, pp. 569-571). Each student's classroom teacher completed the *Behar-Stringfield Behavioral Disturbance Rating Scale* to assess behaviors classified as hyperactive-distractible, hostile-angry, and anxious-nervous (Maxwell, 20003, p. 571). Each student's mother also answered questions that yielded information related to density within the home setting and their child's behavior at home (Maxwell, 20003, p. 571).

In her study, Maxwell suggested that reduced square footage per student (e.g. from 25 feet to 15 feet) has been associated with "increased aggressive behavior, more parallel play in large groups, and less group play" (Maxwell, 2003, p. 568). Results from Maxwell's study of classroom density indicated "behavioral disturbance" scores for boys was higher in rooms with

higher density. Her research also showed that as classroom density increased, girls' academic achievement suffered more than boys' (Maxwell, 2003, p. 576). In the same research, Maxwell suggested that teachers in high density classrooms may be "more distracted." Teachers in charge of classrooms with limited square footage per pupil may spend less time traveling around the classroom, which may mean students receive "less personal attention" (Maxwell, 2003, p. 576). Ramli, Ahmad, Taib & Masri (2014) have suggested that in high-density classrooms, teachers are more likely to arrange desks in rows and columns. This seating arrangement is useful for controlling "students' behaviours [*sic*], and students' discipline within the classroom" (p. 268).

Communication

Powell and Caseau (2004) literally "wrote the book" on classroom communication. The authors devoted the second chapter of *Classroom Communication and Diversity: Enhancing Institutional Practices* (2004) to providing an overview of classroom communication processes. They open the chapter by describing the "effects of classroom communication as circular" and go on to say that it is "difficult to determine" exactly how they influence "learning and achievement" (p. 31). Considering the authors' assertion that it is difficult to determine exactly how the effects of communication impact progress, it makes sense that it is challenging to locate concrete evidence in existing academic literature that provides quantitatively reasoned evidence supporting the relationship. Communication is, however, critical to student progress. Powell and Caseau (2004) do outline research that is helpful when considering the role of communication in shaping classroom ecology.

The authors identify questions, clarity, immediacy, and communication apprehension as four factors that are critical to nurturing classroom communication (Powell & Caseau, 2004, pp. 32-33). With respect to questions, Powell and Caseau cite evidence that "student achievement is

enhanced when teachers ask clearly phrased questions, probe student responses, redirect questions to nonparticipating students, wait for student responses, and provide feedback" (2004, p. 32). Teacher clarity refers to specific behaviors that include stressing important elements of lesson content, incorporating examples into instruction, and assessing and responding to areas of weakness. When teacher clarity is strong, students are likely to demonstrate higher achievement levels (Powell & Caseau, 2004, p. 32). The same is true for teacher immediacy. Existing research referenced within Powell and Caseau's work (2004) shows that immediacy is considered of great consequence for student progress, but the authors also state that existing research does not explain why perceived associations between immediacy and progress exist (p. 35).

The authors gave considerable attention to the concept of communication apprehension. Powell and Caseau wrote that "literally hundreds of studies have been done" and described the results as consistent (2004, p. 36). There are four ways that apprehension can manifest in communication: "internal discomfort, communication avoidance, communication withdrawal, and overcommunication" (Powell & Caseau, 2004, p. 36). When someone experiences a form of communication apprehension, they may experience a physical response ranging from a warm flushing sensation to extreme anxiety or terror. When someone associates a negative reaction with communication, it can lead to avoidance that can manifest as physical or psychological withdrawal or even complete avoidance (Powell & Caseau, 2004, pp. 36-37). When students partially or completely retreat from school activities as a consequence of communication apprehension it can result in diminished academic performance, poor attitudes toward school, and fewer friendships (Powell & Caseau, 2004, p. 37). Powell and Caseau cite evidence from Comadena and Prusank (1988) that found "students who had high communication apprehension

received the lowest scores on all measures of academic achievement" (2004, p. 37). In situations in which a student demonstrates communication apprehension, it is critical to their social, emotional, and academic growth that they receive positive reinforcement for what communication they do share.

When educators consider how a student functions within a particular classroom ecology, it is important to think about how the teacher communicates and how he or she encourages student communication. Both staff and students must be able to clearly communicate in classrooms. When children do not have opportunities to communicate their needs (make choices or requests, provide responses), their opportunities for social and emotional growth are limited. Gregg (2017) states that for a student to develop social and emotional competencies, she or he must have "a communication system…to appropriately express emotions and have their social needs supported" (p. 446). Inability to communicate needs can often result in "inappropriate, alternative options for social exchange," which may look like challenging behaviors (Gregg, 2017, p. 446). Students who display challenging behaviors require an individualized communication system so that they can both express needs and develop social skills. For students who struggle in the area of communication, staff members should make a concerted effort to use strategies such as sign language and visual symbols to meet needs.

While it is difficult to locate research providing clear methodology and strong evidence supporting the linkage between communication and student progress, we know that they are strongly linked. The information provided in the preceding paragraphs is meant to provide some foundational knowledge that supports the importance of considering communication when evaluating how a student functions within a particular classroom ecology.

Individualized Instruction

Not all teachers are equipped to handle the various needs present in the classroom. Effective teachers incorporate multiple instructional strategies and respond to students' unique needs in each lesson, a method known as differentiation (Tomlinson and Cunningham, 2003; Watts-Taffe, Laster, Broach, Marinak, McDonald & Walker-Dalhouse, 2012). Tomlinson and Jarvis (2009) provide a definition of differentiation that succinctly states its importance for meeting all learners' needs:

> Differentiation is an approach to curriculum and instruction that systematically takes student differences into account in designing opportunities for each student to engage with information and ideas and to develop essential skills. Differentiation provides a framework for responding to differences in students' current and developing levels of readiness, their learning profiles, and their interests, to optimize the match between students and learning opportunities. These three dimensions of student difference can be addressed through adjustments to the content, process, products, and environments of student-learning, and each is justified by a research-based rationale (p. 599).

Differentiation requires teachers to constantly monitor and skillfully respond to individual learner needs, and differentiation most commonly occurs through content, process, and product.

Tomlinson and Cunningham's (2003) definition of content "refers either to what a student should come to know, understand, and be able to do as the result of a segment of study, or to how the student will gain access to that knowledge, understanding, and skill" (p. 10). Content differentiation means that all students learn the same themes and concepts, however, the teacher may select specific curricula to meet students' needs or offer "additional resources that match students' levels of understanding" (Tomlinson & Allan, 2000; Hudson, 2018).

Process is, according to Tomlinson and Cunningham (2003), synonymous with "activities" (p. 10). Differentiating the learning process involves providing students with multiple ways of learning the same themes and concepts at the center of the learning objective. A teacher who differentiates process might make intentional connections between students' (or a student's) lived experiences and interests and the lesson content, vary opportunities for learning the material, and allow students autonomy in determining how they will learn the content (Tomlinson, 2001; Watts-Taffe, et al., 2012, Dixon, Yssel, McConnell & Hardin, 2014). Lessons that involve effective activities are "focused squarely on the key knowledge, understanding, and skills central to a segment of study and call on students to grapple with the content so they come to 'own' it" (2003, p. 10).

When Tomlinson and Cunningham (2003) uses the term "product," they are referring to the student-produced evidence that shows what they know as a result of the learning process. Differentiating the product allows students to demonstrate understanding or mastery of the lesson's objectives in a way that is appropriate for their ability. Differentiated products also allow teachers to assess knowledge in a variety of ways (Tomlinson & Allan, 2000).

CHAPTER III: APPLICATION OF THE RESEARCH

Evidence-Based Rationale

Minnesota Rule 8710.5000 *Core Skills for Teachers of Special Education* subpart 2 B requires that special education teachers understand and apply "principles of prevention" and early intervention and the "procedures for referral assessment, evaluation, individualized planning, programming, and placement." The rule goes on to state that special education teachers must be able to "assess the impact of environmental factors on assessment results and the special education evaluation, planning, and programming process" (September 12, 2018). Despite this requirement, the three school districts in which the researcher has been employed or student taught did not formally consider environmental factors at any point during the pre-referral or evaluation processes. Given Minnesota Rule 8710.5000, the decades of research showing "compelling evidence that the classroom environment is such a potent determinant of student outcomes that it should not be ignored by those wishing to improve the effectiveness of schools" (Fraser, 1986, p. 1), and the fact classroom environment is not routinely considered when evaluating individual student needs, it is of great importance that researchers work to build a research-based tool that can be used for assessment purposes.

The literature review preceding this section provided background information explaining the significance of the various factors that influence classroom ecology. Having examined key aspects of classroom ecology, the question becomes: what next? To help teachers and administrators use the information in a productive way, the content provided for each factor discussed in the literature review has been reduced to its most significant elements and used to create a Classroom Ecology Quality Indicator Tool.

Project Description

The Classroom Ecology Quality Indicator Tool uses information from the literature review to identify criteria considered critical to ensuring students are learning in spaces that promote their academic and behavioral growth. The tool, which is provided on the following page, represents an initial attempt to clearly and simply define what administrators and educators should look for when assessing classroom ecology. The Classroom Ecology Quality Indicator Tool is made up of 22 indicators. Indicators are the pieces of evidence or clues that evaluators use to measure the quality of something. Often, indicators are rooted in theoretical research that academics and other experts have tested and determined to be true. Researchers can then take that information and break it down into its most important parts – this is how indicators are identified. Indicators are then incorporated into a larger tool that can be used to measure how close something – a program, a resource, a classroom – is to what might be considered best practice. It eliminates jargon and academic language and presents indicators that are clearly defined. It is meant to be quick and provide immediate feedback as to criteria that may require adjustment.

Sixteen of the indicators are related to the physical elements of the classroom; the remaining six are related to social components of the classroom. Together, they shape the classroom's ecology. The researcher considered various formats for presenting the indicators. A rubric was initially considered but ultimately deemed to not be the best option at this point in the evolution of the tool. Instead, the researcher opted for a checklist. If the indicator is present, its corresponding box is marked. If the indicator is not present, the box is left empty. Empty boxes

Classroom Ecology Quality Indicator Tool

Item	Criteria	Present
	Physical Environment	
1	Classroom walls are appropriately decorated, with 20%-50% free of decoration.	
2	Classroom walls are predominately neutral in color.	
3	Classroom furniture and surfaces are neutral in color.	
4	Internal noises are minimal (chair feet are padded, teacher has command of volume levels during various instructional activities, classroom has a wall and door separating it from shared space).	
5	External noises are minimal (little noise from outside of the building such as playground noise, vehicle traffic, etc.).	
6	Teacher uses a voice augmentation device to ensure all students hear.	
7	Full-spectrum lighting is used for overhead lighting.	
8	Lighting is supplemented with local light sources, such as floor lamps.	
9	Classroom has a window.	
10	Classroom window is free of obstructions, allowing sunlight in and students to look outside.	
11	View from the classroom window is unobstructed for a minimum of 50 feet.	
12	Classroom temperature is between 68-75 degrees Fahrenheit in the winter and 72-79 degrees Fahrenheit in the summer.	
13	Classroom has a thermostat.	
14	Carbon Dioxide levels are below 1000 ppm.	
15	Classroom has at least one window that can be safely opened to promote ventilation.	
16	Classroom window provides visual access to nature.	
	Social Environment	
17	Classroom teacher exhibits high expectations for all students.	
18	Classroom teacher promotes a sense of community for all students.	
19	No record of teacher-student conflict.	
20	Students have multiple opportunities and methods of communicating needs.	
21	Classroom square footage is about 25 square feet/student.	
22	Evidence of classroom teacher differentiating instruction to meet the individual learner's needs.	
		TOTAL

Comments:

represent indicators requiring improvement. A score of 22 suggests the classroom ecology reflects best practice and is optimal for student learning. Any score below 22 indicates there is work to be done in order to improve the health of the classroom's ecology. Since the purpose of the tool is to determine how classroom ecology might impact an individual student's academic performance and/or behaviors, it is important that each indicator identified as not present in the classroom should be taken into consideration during the evaluation process.

The ultimate purpose of Classroom Ecology Quality Indicator Tool is to provide administrators and educators with a resource that allows them to meet the standards clearly established in Minnesota Rule 8710.5000. If student evaluations are required to consider environmental implications on student performance, then they need to be provided with a tool that allows them to consider its impact as objectively as possible. The tool could be used so that it measures only physical aspects of classroom environment but broadening it to include social implications allows professionals to consider the ecological health of the learning space. It is by no means authoritative or definitive; it is very much a work in progress.

Audience

The Classroom Ecology Quality Indicator Tool is meant to be used by professionals in the field of education. Special education professionals do not need additional paperwork; their workload already exceeds what can be done in a regular workweek. However, given Minnesota state laws require special education professionals to critically consider the role of environment in shaping student performance, a tool like the Classroom Ecology Quality Indicator Tool should be seriously considered. The tool's content is meant to be easily understood and the form can be completed in less than 10 minutes. While the tool was developed to be used during special

education evaluations, it could easily be used during pre-referral interventions and by teachers who are interested in improving the overall health of their classroom's ecology.

The fact that Minnesota Rule 8710.5000 mandates teachers to consider the impact of environment on student performance means that the state of Minnesota's Department of Education should also communicate the importance of using a tool such as the Classroom Ecology Quality Indicator Tool during evaluations. Creating buy-in for incorporating the tool into pre-referral interventions and special education evaluations should start in college courses. Future educators need to be made aware of the range of factors that define a classroom's ecology and the range of potential impacts a classroom's ecology can have on academic performance and behavior. It may also increase buy-in to include professional development focused on classroom ecology at regional and national teaching conferences and articles in trade journals.

Resources

This project is in its early stages. The literature reviewed for the project identified twenty-two key indicators that shape a classroom's ecology. Those indicators were then incorporated into the first version of a tool meant to measure the health of a classroom's ecology. Before the Classroom Ecology Quality Indicator Tool can be presented as a valid instrument and considered during a special education evaluation, however, it must be thoroughly tested and refined.

There are several resources impacting the development and use of the tool, including people, money, and time. The early stages of testing the tool would involve teachers providing data and feedback. Depending on how the tool takes shape, it may be necessary to test the tool on a range of students – both special education and general education students – in order to measure the validity of the tool. This would significantly increase the number of people involved in the

study. The project's researcher would also want to meet with leaders in the field of special education (academics, special education administrators, seasoned special education teachers, professionals at the Minnesota Department of Education) to solicit input on the tool.

The cost of continuing to develop the Classroom Ecology Quality Indicator Tool would mostly impact the personal finances of the researcher. Developing the tool would require the researcher to step away from her current teaching position in order to return to school and focus on the tool. While some of the research may be accomplished while the researcher is teaching, it will likely be necessary to have one to two semesters during which she can focus on developing the tool and testing it in various different settings. There should be no other major costs incurred as the project is further developed.

The major resource impacting the development of the tool is time. Continuing to work on the tool will require the researcher to find balance between family, work, and school. This has already proven challenging. However, the researcher firmly believes in the importance of understanding how classroom ecology influences learning and behaviors and feels the investment of time and money could yield results that could significantly impact how educators think about their classrooms.

Sustainability

The sustainability of this project largely depends on two things. First, its sustainability will depend on its impact. If professionals use the tool and find it beneficial during pre-referral interventions and evaluations, this will obviously influence its sustainability. If professionals use the tool and most do not consider it useful, it will signal the tool needs to be revised. Second, its sustainability will depend on the ability of its author to keep it up-to-date. Ensuring it reflects the most recent research will be critical to ensuring its continued use. This will require frequent

review of new studies related to classroom environment and classroom ecology and the continued solicitation of feedback from professionals knowledgeable of and/or using the tool.

CHAPTER IV: DISCUSSION AND CONCLUSION

Summary

The introduction to this project presented the idea that a classroom should be considered as a unique type of environment, and that its social and physical components interact with each other to create a unique type of ecology that directly impacts academic performance and behavior. A literature review related to the idea of classroom ecology revealed that while there are a number of articles focused on individual factors influencing student performance and behaviors, there is a paucity of academic research combining factors into a single study. Furthermore, very little research is written in a way that makes it accessible to teachers (for an exception, see Guardino & Fullerton, 2010). Existing literature also does not include a tool for evaluating the health of a classroom's environment or ecology. This is interesting when one considers that in the state of Minnesota, and one might surmise is also the case in other states, special education teachers are required to consider how environment impacts student performance. In response to the lack of research focused on ecological considerations in special education, this project accomplished two things. First, it reviewed academic literature and identified key indicators of a healthy classroom ecology. Second, using the twenty-two identified indicators, a tool was created to determine how a classroom's ecology might impact learning and behavior.

The indicators covered in the Classroom Ecology Quality Indicator Tool are the result of an extensive literature review that encompassed a range of diverse factors. Guardino and Fullerton (2010) went so far as to state there is minimal research exploring how environmental modifications impact behavior and learning. If the research duo focused their research exclusively on educational journals, this might be true. As was evidenced in the literature review for this project, there is a wealth of information available in non-educational journals that

accomplishes this task. However, the fact that Guardino and Fullerton (2010) stated there is a paucity of information in education journals raises a red flag. If we have evidence that classroom ecology impacts student behavior and academics, we need to make that information both accessible to and useable by teachers and administrators.

Professor Peter Barrett has partnered with various academics to study the impact of the built environment on student success. Barrett and his colleague have published some of the few studies that move beyond examining one environmental factor to combining factors into a single study (Barrett & Barrett, 2010; Barrett et al., 2013; Barrett et al., 2015a; Barrett et al., 2015b; Barrett et al., 2017; Barrett et al., 2011; Barrett & Zhang, 2016). In addition to identifying some of the key indicators used to inform this project, Barrett and his colleagues also determined that school-wide factors should not be considered main factors influencing student progress. Instead, the "overwhelming focus" should be at the level of the individual classroom (Barrett et al., 2015b, p. 15). When we consider the results of Barrett et al.'s (2015b) holistic approach to studying the impact of the physical environment on student performance – the researchers attributed "16% of the variation in the overall progress" of the study's students to the influence of the "overall design of the physical learning space" – two things become abundantly clear (p. 14). First, further research is necessary. Second, researchers should actively promote their work to increase understanding regarding how the physical and social components of learning spaces impact student success.

The literature reviewed for this project yielded 22 indicators that give shape to classroom ecology. Most of the indicators are concrete measurements that comprise a classroom's physical environment, such as visual stimulation (Godwin & Fisher, 2011; Hanley et al., 2017; Fisher et al., 2014; Rodrigues & Pandeirada, 2018), color (Jalil et al., 2012; Stern-Ellran et al., 2016),

sound (Crandell & Smaldino, 2000; Kanakri et al, 2017; Oliveras-Ortiz, 2017; Puglisi et al., 2015; Rosenberg et al., 1999), lighting (Tanner, 2008; Tanner & Lackney, 2006; van Mil et al., 2018), temperature (Haverinen-Shaughnessy & Shaughnessy, 2015; Mandell & Heath, 2005; Wargocki & Wyon, 2007), ventilation (Bako-Biro et al., 2012; Mendell et al., 2016; Petersen et al., 2016; Twardella, et al., 2012), and natural elements (Benfield et al., 2015; Edwards & Torcellini, 2002; Tanner, 2009; Tanner & Lackney, 2006). The remaining indicators are related to the social components of a classroom's ecology. These indicators include social interaction (Buyse et al., 2009; Ciric & Javanovic, 2016; Curby et al., 2009; Farmer et al., 2011; Hendrickx et al., 2016; O'Connor, 2010; Reinke & Herman, 2016; Rex et al., 2006; Roseth et al., 2008; Wentzel & Caldwell, 1997), classroom density (Glass et al, 1982; Ehrenberg et al., 2001; Maxwell, 2003; Ramli et al, 2014), communication (Gregg, 2017), and individualized instruction (Jarvis, 2009; Tomlinson & Allan, 2000; Tomlinson & Cunningham, 2003; Watts-Taffe et al., 2012). The breadth and depth of existing research related to the individual indicators included in the Classroom Ecology Quality Indicator Tool is evidence of the need for a formalized tool that can be used to assess what factors might influence a student's ability to thrive.

Professional Application

There are few tools that can be used to formally assess the environmental or ecological health of a K-12 classroom. This has been made abundantly clear through this project. The researcher did not locate standardized tools. The only tools the researcher is aware of are the informal assessments provided to her by an instructor that were mentioned in the introduction to this project. At a broad scale, the Classroom Ecology Quality Indicator Tool is something that can be used by teachers and administrators even prior to intervention. It could help ensure teachers are doing what they can to meet best practice standards. It may also bring awareness to

the diverse factors that shape a classroom's ecology. This increased awareness may influence teachers to carefully consider the places they create for their students.

In Minnesota, specifically, Minnesota Rule 8710.5000 requires that special education teachers can "assess the impact of environmental factors on assessment results and the special education evaluation, planning, and programming process" (September 12, 2018). Completing this task is challenging, however. To date, the researcher has not identified a school district in the state of Minnesota that includes environmental assessment during the pre-assessment or evaluation process. It is time for the creation and implementation of a research-based tool that allows special education teachers to ensure students receive a fair evaluation that takes into consideration the spaces in which they learn.

Limitations of Research

One limitation of this research was the lack of existing evidence focused on the idea of classroom ecology. It was far easier to locate information related to the physical environments of classrooms than it was to find research on the social environments of classrooms. Future research into the development of the Classroom Ecology Quality Indicator Tool will necessarily require extensive research related to the social indicators proposed in this study. This component of the research will require more time and resources than were available during this initial phase of research. However, the information reviewed in this project's literature review provides a foundation for that future resource and identified social indicators that should be included in any tool used to evaluate classroom ecology.

Initially, the researcher planned to develop a tool that resembled a rubric. Each indicator would be measured so that a classroom could be receive a score of zero (no evidence) to three (best practice) for each indicator. While developing the tool, however, the researcher determined

it was most reasonable at this point to present the indicators in a checklist. Using a checklist allows the evaluator to analyze a complex subject, such as classroom ecology, based on the presence or absence of key indicators. The researcher's current perspective is that a classroom should not be rated on a scale for each indicator. There is not a magic cutoff number that determines a healthy or unhealthy level of classroom ecology. Instead, the purpose of the tool is to provide a list of best practice indicators. If an indicator is missed, it is a topic that needs to be addressed or taken into consideration by the evaluator as they consider the student's needs.

Implications for Future Research

This project represents the initial step in what the researcher considers to be a much larger, more complicated project. While the Classroom Ecology Quality Indicator Tool proposed in this project is based in existing research and could be used as part of a pre-referral intervention or evaluation, the researcher acknowledges there is considerable room for its development. The tool should be tested and refined in real-life situations in order to determine if it has value and can effect change. For example, if the classroom's temperature is measured to be too warm, the classroom's walls are visually overwhelming, the level of carbon dioxide is high due to poor ventilation, and the teacher is overly critically toward one student, did correcting those issues positively impact change? What corrections were recommended? How were the corrections implemented? How long did it take before changes were evident? This type of data will take a minimum of several months or longer to collect and interpret and is critical to creating a valid tool.

Conclusion

This purpose of this project was twofold. First, the researcher set out to evaluate existing literature in order to determine what is known about the impact of environment on students' academic performance and behavior. Second, the researcher wanted to use the key pieces of information from the literature review to create a tool that could be used to evaluate the impact of classroom ecology on students. Both tasks were accomplished. In doing so, the researcher created an initial draft of the Classroom Ecology Quality Indicator Tool, a resource that lists 22 indicators that teachers and administrators should take into consideration when evaluating how students' academic performance and behaviors are shaped by the spaces in which they learn. While the tool provided in this project represents a first attempt, it is an important advancement in ensuring students' needs are appropriately evaluated.

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