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12. THE GEOGRAPHY OF GIFTEDNESS

Growing Scientists in Rural Areas

INTRODUCTION

Rurality is best understood, not by census information, but by examination of the *space* between people. Distance between people and resources shape rural culture; and space can propagate independence, adaptability, lateral and critical thinking, and creativity. Sparse distribution of people impacts how residents approach problems and their exposure to new ideas; geography and population affect funding of essential services such as public education due to a marginal tax base. This chapter addresses three issues that impact transition of gifted rural children to university settings and, subsequently, into Science, Mathematics, Engineering, and Technology-oriented (STEM) careers: 1) an examination of space and an overview of rural communities and schools; 2) rural gifted students' readiness for university science studies including place-based knowledge, skills, and impediments, and 3) a possible plan-of-action leading to a science-oriented career trajectory linked to rurality. Although some of the following discussion focuses on culture and education in rural south-western United States, research indicates that space has a similar effect on children worldwide.

THE SPACE BETWEEN

Geographic Isolation

> Between Portales and Roswell, New Mexico lies one-hundred forty kilometres of mesquite, yucca, and sage. Well-kept dirt roads on either side of the highway indicate the presence of a ranch or oil field. Unlike major thoroughfares in urban areas, this stretch of four-lane highway contains no exit ramps, no advertisements, and cell service is intermittent at best; in fact, only one community is large enough to support a small convenience store and school (enrolment – 142 students pre-kindergarten to grade 12). Recognised for its high standards, the school operates on a 4-day week with sixteen teachers.

Geographic isolation impacts most aspects of daily life in rural America, and parallels exist with remote locales anywhere on earth. A study of space provides insights into physical, cultural, and economic factors that shape lives. As in the example above,

M. K. Demetrikopoulos & J. L. Pecore (Eds.), Interplay of Creativity and Giftedness in Science, 219–239.

somewhat innocuous aspects of where one lives mould, and sometimes dictate, a life path. An examination of rurality indicates that the environment is science-rich though relatively technology-poor, requires a high degree of independence and ability to problem-solve, but rarely meets the needs of gifted children in formal educational settings. Foundational to understanding the plight of children raised in predominantly agrarian communities is the fact that opportunities for some facets of growth and change may be restricted, but are not fixed. Since forty percent of American children attend rural schools, educators must devise place-conscious strategies to better help all children reach their potential (Kordosky, 2010).

Rural residents enjoy many benefits of living outside densely populated areas. Rurality is relatively free of crime, aesthetically pleasing, and quiet with less stress. Closely associated with the land, many country dwellers choose to maintain gardens and attend to livestock, freeze and preserve home-grown foods, and participate in environmental and conservation practices in varying degrees. Children in remote settings are often more in touch with nature and understand the relationships among space, wildlife, water, resources, and humans. Parents wishing to manage children's social and educational lives may have a distinct advantage by living without many distractions of urban areas.

Space governs what one can and cannot access. The absence of health services, home repair specialists, and markets in rural areas breed independence and flexibility – the phrase “rugged individualism” spawned by settlement of America’s frontier is still applicable to many rural residents today. Electricians, plumbers, and carpenters are expensive luxuries and most tradesmen are unwilling to travel to remote sites for small jobs. Consequently, many rural residents become quite adept at do-it-yourself home repairs and routine maintenance. The independence bred by isolation is not necessarily recognized as understanding of scientific principles, ability to solve difficult problems, or indicators of giftedness by those living in rural areas.

Rurality also severely restricts employment opportunities and may limit children’s options for future jobs regardless of their creative abilities or level of giftedness. Most rural residents work in agriculture or mining/energy extraction. Employment in these jobs tend to be inter-generational and often, children see few opportunities for work beyond the occupations of their parents and may feel bound to the open land. Community values and families’ expectations have profound impacts on career and educational choices made by children (Hardre, 2009). Attempts to leave rural areas in pursuit of a better life may be viewed as “destabilising” to the community (Howley, 1998 cited by Lawrence, 2009). Rural families are among America’s poor with average annual incomes of $36,920 (U.S. Census, 2010). Average wages for agriculture non-management workers in agriculture is $22,118 per year; miners and oil workers fare better at $42,240 annually (USDA, 2012; Technomine, 2012). These income data are easily misconstrued due to variability based on region, race, and annual versus seasonal employment; for example, 2010 data reveal that poverty in some rural population pockets in the United States approaches 50 per cent (Housing Assistance Council, 2012).

Geography's Effect on Schools and the Gifted

Like the environment in which they exist, rural schools are best characterised by extremes. In urban areas where political discussions include terms such as "competition" and "charter schools", rural schools are often the only viable option for children in remote areas. Consequently, some rural schools' heightened visibility and status within the community yield positive results. In a recent assessment of schools in New Mexico, outlying districts tended to receive higher marks overall that their urban counterparts (New Mexico Public Education Department, 2012); rural schools tended to have higher completion rates, higher tests scores, lower teacher-student ratios, and greater involvement of parents in all aspects of the educational process.

Although rural children enjoy benefits of small class size and more individualised attention, little research exists touting the advantages of being gifted in rural schools. Based on the body of current research, the state of rural education and the ability to serve gifted students seems quite bleak (Floyd, McGinnis, & Grantham, 2010). Decreases in budgets, non-compliance with state and national special education regulations, and lack of well-trained teachers does not bode well for creative children. According to Stambaugh (2010), rural communities' allocation of resources, classroom issues, teacher preparation and pay, educational attainment, and parental expectations are reasons for concern. Rural schools' inability to serve bright children results in boredom and general dislike for schooling (U.S. Dept. of Education, 1993).

Despite state and federal laws and regulations, few rural schools can sustain comprehensive special education programs and rural school administrators often view gifted and talented (GT) program services as optional. Using traditional measures of giftedness, the prevalence of gifted students at approximately two percent of the general population (intelligent quotients of 132 or above) underscores the problem (Gifted Development Centre, n.d.). Since most rural schools have enrolments of 400 students or less, separate GT programs comprised of eight to ten students are fiscally unsustainable. Many gifted educators assert that rural schools have no option (legally and morally) other than to serve the needs of bright, creative children. Kordosky (2010) states that forty per cent of children in the United States attend rural schools and assuming that giftedness is uniformly distributed across rural populations, gifted rural students are an untapped resource that demands attention and support.

Lawrence (2009) offers a practical rationale for why society should care about gifted students in rural areas – the obvious argument for enriched education for rural children is that they deserve every opportunity to reach their potential. No less important, and closely aligned with the concept of space, is that "rural communities cannot afford to lose the contributions gifted students can make to rural community, culture, and economy" (p. 462). Despite strong justifications for educational support of bright children, special education and gifted education services in rural schools tend to be uneven and student services are prioritised based on numbers and demand. Gentry et al. (2001) examined trends in rural schools associated with gifted education; they found that schools were less likely to provide appropriate placement and services because of program novelty (unproven or lack of empirical support), lack of financial support for programs, and low enrolment rates for gifted students. Other research suggests that most rural schools utilise differentiated instruction strategies to meet the needs of gifted children rather than allocation of additional personnel with specialised training (Stepanek, 1999). Kordosky (2010) dedicated a chapter in his book, *Rural Gifted Children: Victims of Public Education*, to extreme measures to force rural school districts to provide appropriate services to gifted children including litigation. However, Kordosky does not take in consideration rural culture and the implications of suing one's neighbour in a tightly knit, interdependent community.

A debate among gifted educators provides hope for rural GT programs. Since a link exists between resources available and numbers of students served, the modern gifted education movement advocates use of broader criteria for selection of gifted students. Traditionalists associate gifted abilities with intelligence quotients, yet IQ may not be the most reliable predictor of ability or performance (Matthews & Kelly, 2007). In addition to IQ, advocates urge use of criteria that include observations, interviews, performance data, and results from other standardised tests to determine whether students are gifted (Lawrence, 2009). A supporter of more flexible admission criteria for rural gifted programs, Stambaugh states, "Rural gifted students, especially those who are geographically or financially disadvantaged, show their talents in different ways and, therefore, may require multiple assessments to capitalise upon their unique needs." (p. 66) Brown, Renzulli, and others (2005) report that most special education administrators believe that objective measures as intelligence quotients tests must be used to assess gifted, but one-third of respondents in their research would like to include personality traits or performance-related criteria. These researchers concluded that how giftedness is identified is based on two questions or beliefs:

- Is giftedness an absolute or relative concept? That is, is a person gifted or not gifted (the absolute view) or can degrees of gifted behaviours be developed in certain people at certain times under certain circumstances (the relative view)? and
- Is giftedness a static concept (you have it or you do not have it) or is it a dynamic concept (it varies within the individual and learning/performance situations)? (p. 77)

If one believes that giftedness is relative, dynamic, and should be assessed using performance measures in addition to IQ tests, then numbers of children are likely to increase adding emphasis and legitimacy to rural gifted education programs.

Other challenges faced by rural schools are linked to personnel. Teachers and administrators in rural areas may be similarly place-bound as the students resulting in low attrition; when teachers do move or retire, schools may have difficulty recruiting replacements due to lack of housing and shopping or daunting commute times (Fowler et al., 2013). Some rural schools districts request emergency waivers from state education agencies to place non-certified or non-licensed personnel into classrooms. States with large rural populations are forced to offer alternative routes to licensure; these alternative licensure programs do infuse more teachers into the workforce, but attritions rates are high and self-efficacy to teach was low among those who participate in abbreviated preparation programs (Darling-Hammond, 2002). Alternative licensure programs may consist of as few as six university courses beyond an undergraduate degree. States employ a patchwork approach to alternative licensure in special education and an endorsement in gifted education can be secured after 12 hours of select university coursework (New Mexico Public Education Department, 2012). However, organisations such as "Teach for America" provide extensive professional support and other incentives for newly certified teachers seeking employment in rural areas.

The combination of low income and low taxes on agricultural properties results in difficult choices in funding services for rural populations. Monies that support schools are unevenly distributed across county and state boundaries. With local funding in decline, rural schools survive on small budgets; and since salaries and benefits make up nearly forty per cent of most school budget, rural schools operate with the least number of teachers and staff possible (Fiscal News, 2011). However, some innovative rural districts have entered into collaborative agreements in order to secure highly qualified personnel to work with students with special needs such that two or more small districts may share special education teachers in order to offset costs, comply with laws and regulations, and still attend to the needs of children with special needs. These shared teachers work in participating schools a few days per week and collaborate with regular classroom teachers in providing prescribed services. Other personnel issues affect rural education – teachers often instruct outside their area of expertise (Kordosky, 2010). For example, a rural school's mathematics teacher may serve as the science teacher and administrators may encourage physical education teachers to seek endorsements in special education. Offering advanced classes in mathematics, science, and foreign languages can be particularly difficult, in part, because rural districts are less able than others to attract teachers with specialised preparation and rural high schools are less likely offer a full complement of Advanced Placement (AP) courses (Lawrence, 2009). A school district's inability to provide advanced science and mathematics courses will impact students' attitudes toward science and their transition to entry level university courses (Everhart, 2012).

Little research exists that guide rural districts' efforts to improve the plight of gifted children. Arnold et al. (2005) state that funding for high quality educational research in rural settings is limited and that the few studies that have occurred are framed in a context used to preserve rural schools rather than to identify issues affecting quality of services. In his meta-analysis of reform research conducted in rural settings, Arnold found that researchers typically conducted only one or two formal substantive studies per year in gifted rural education in the United States.

Since the mid-1990s, the National Science Foundation through its Rural Systemic Initiative (RSI) has made strides to document exemplary programs, curricula and instruction reforms and improvements in policies and infrastructure that address needs of rural children while promoting science. RSI identified six "drivers" or tenets of change that include classroom, policy, resource, community, attainment, and equity (Systemic Research, 2005). Rural districts may use data collected in these programs to inform future decisions regarding funding, personnel, academic choices, and partnerships.

SPACE AND THE NATIVE SCIENTIST

In the previous section, issues relating to isolation and the effects on community and schools were explored. Although gifted students in rural schools do reap some benefits from the inherent structure of rural education including smaller class size, educational literature more often associates rurality with adversity. If gifted students' psychological needs are not being met by schools, and if they do not master requisite content knowledge and skills, then, are the rural gifted viable candidates for STEM-oriented careers – or are they, as VanTassel-Baska and Stambaugh described, "overlooked gems"? (2006).

Place-Based Science

Little primary research is available dealing with the interplay of "science careers, giftedness, and rural children." Some extrapolation is necessary to develop a complete picture of rural gifted students' potential as future scientists. With considerable variability among children identified as gifted (IQ, motivation, support from parents, economics, community values) and trends to use performance criteria when identifying gifted students, the issue of "space" provides a unifying concept among children raised in remote areas. Briggs, (2005) posited that the depth of the enculturation of local values and knowledge may facilitate positive change in rural areas. He stated that "local embeddedness of indigenous knowledge that imbues it with relevance, applicability and even power" (p. 21). Like their parents, space impacts young children's lives determining the types of play experienced, hobbies, and pastimes. Children play an integral role in the operations of the rural home. Farm life may dictate early assumption of chores and responsibilities for children (Extension, 2013); in eras before mechanisation, ranchers maintained large families that served not only as stabilising units for rural communities, but children contributed significantly to the workforce. During that time, adults passed skills and knowledge to children about animal husbandry, crop maintenance, food preparation, and considerable adroitness with hammers and saws – without regard to gender. Parents prepared children to be "generalists" or "jacks/jills-of-all-trades". Space and necessity of that period required children to assess issues as they arose, collect available information, consider and select appropriate solutions, and reflect on outcomes (Inwood, 2013).

The development of skills, acquisition and retention of useful knowledge and mastery of processes for making sense of the world are foundational to survival in rural areas, but these qualities are also fundamental to becoming successful scientists. Some data and anecdotal information suggest that native knowledge that is common to rural living might well serve as the precursors for careers in science (Avery, 2013). Coupled with traits of the gifted that include innate curiosity, persistence, ability to analyse and consider options, rural children offer a formidable repertoire of skills if they enter STEM-based jobs. In order for any knowledge and skills acquired in a rural context to be useful in transitioning to a university, two criteria must be met: 1) students and other rural constituencies must be able to connect their knowledge of the world to formal science and 2) children must see themselves as “native scientists”.

Some research in science education shows that students are capable of linking their rural existence with scientific concepts. Avery and Kassam (2011) asked fifth and sixth graders to take photographs of elements of rural living that were representative of science and engineering concepts. The researchers conducted individual interviews with children to probe further the depth of student understanding. Based largely on Aristotle’s supposition of “phronesis” or practical wisdom, the researchers attempted to determine if the children could make connections between their indigenous knowledge and science; the investigators also tried to locate sources from which native knowledge was derived. Avery and Kassam arrived at five key findings. They found that 1) students were able to identify science and engineering concepts embedded in rural living; 2) students learned about the scientific concepts by observing or doing (or both); 3) the primary source of information about native science was the family; 4) children used daily activities to understand science; and 5) students’ understanding of place-based science was not fully formed and was dependent upon teachers and others to help students make relationships between practical wisdom and traditional classroom science. Although many of the students photographs were not exclusive rural existence (auto mobiles, gas grills, toys), this research suggest a strong link between rurality and native science.

In a similar study, Lloyd (2010) attempted to determine sources or “funds” of science knowledge from rural children. As in the Avery and Kassam research, some students’ responses were not restricted to rural living. Lloyd developed criteria for separating general science concepts from those exclusive to living in rural areas. He found that students had place-specific understanding of water, farming, transportation, outdoor recreation, local geography, and knowledge associated to their parents’ employment. Students in this study believed that certain conditions are necessary to glean value in their funds of knowledge. Students thought that any complementary science studies should mirror their way of understanding the world – activities should have local relevance, learning should occur in small teams, and science should involve hands-on activities and fieldwork. Participants expressed the importance of establishing community, possibly in the form of a club or student organisation, in order to help them learn science. Students liked the idea of working teams because they were closer to content, were able to manipulate equipment, and were not resigned to watching others complete tasks. Several of the student participants also expressed the importance of using authentic equipment, performing "real" science, and having active field experiences. The children indicated that a realistic context made the investigation seem like the type of science that scientists would do, not just learning things for a test. Many of the students' preferred learning styles reflected learning and work conditions common to farms and ranches.

Insights from the Ranch

In order to confirm some of the findings in the Avery and Kassam and Lloyd research, the author of this chapter sought addition information from resident experts in rurality, indigenous science, and gifted education (Everhart, 2012). Patrick and Robin Wallace (pseudonyms) are life-long residents of rural Colorado and New Mexico. They have two children and five grandchildren. Uniquely qualified to provide insights into rural living, Patrick and Robin are retired teachers; also, Patrick was a special education coordinator in a Colorado school district. The Wallace's are a mid-generational rural couple – *recipients* of information and skills from parents and community, as well as *transmitters* of rural culture to their own children and grandchildren. In a recent interview, Mr. and Ms. Wallace shared pertinent background about how they acquired science-oriented knowledge, the transference of their place-based knowledge to their children and grandchildren, and how skills, much of which learned sixty years ago, continue to serve them on their ranch in in rural, New Mexico.

Five themes emerged in their accounts of rural living: 1) parents and members of their community influence what and how rural children learn; 2) isolation affects the types of work and entertainment in which rural children engage; 3) families that exhibit and value inventiveness and creativity transition more easily to university settings and to STEM careers; 4) problem-solving on the ranch resembles some elements of the scientific method; and 5) rural children learn by doing. These themes underscore the convergence of creativity, science, and dictates of rural living.

Science is an integral part of growing up in a rural setting. Robin responded first to an open-ended question regarding an early experience that she believed had a basis in science. She shared that her mother frequently made pies for the family and since the family's orchard seldom produced much fruit due to lack of water; Robin's pie of choice was chocolate. Due to the delicate nature of a good pie crust and several missteps, Robin was relegated to the low-skill job of stirring the filling. As time passed, her mother taught the nuances of precise measurement and the responsibilities of pie making was eventually passed to Robin. She explained, "With that measurement you had to be real careful. How much water you put in and how much flour." The lesson continues to guide her cooking and the lesson of precise measurement has been passed on to her children.

Patrick recalled several stories of his youth; his accounts focused on getting information about the world from experts outside his immediate family. He shared that during summer months that he, his brother and their friends would pitch tents in the pasture. Before they slept, the group would spend time looking at the stars. Patrick continued, "Part of the thing being out there…you could see all the stars and you shared information and looked for different things and you learned about how to find directions…the North Star…and how the Big Dipper could help you find the North Star." Use of directions is a critical part of rural living in the south-western United States. Directional information used regularly includes references to weather patterns, land usage, location of homes and real estate. Patrick's mastery of directions began sixty years ago under star-lit New Mexico skies.

Notable during the interview were several asides about "isolation" and other sources of information made by the couple. Patrick's rural sources of information were more global than Robin's due in large part to space. Patrick had access to other children because his family ran a business; Ms. Wallace had a more classic rural experience noting on a few occasions during the interview that no other children lived near her family's home.

During the last dozen years, the Wallace's have had a veterinarian visit their ranch only once. Both have served as sole health care providers to over five hundred cattle. When asked how they knew so much about animal care, Patrick stated:

> I worked on a ranch when I was 15. The fellow that I worked with had been the vet's helper. And so he did all kinds of stuff. He could deliver Caesarean. So I learned a lot about vet work with him. And also learned stuff from people like Mr. Russell Warner (a pseudonym) at the store in town. He (Mr. Russell) was the same way.not a vet but he worked for one a long time and he handled vet supplies (in his store). He learned what medicines on the shelves did what. So basically, he was a good resource for me. For example, you go to him (Mr. Russell) when you'd say, 'I got a cow with a snake bite.' And he'd tell you how to do it…and different things like that.

The discussion of science concepts utilised by rural residents led to another relevant issue – how "space" nurtured development of expertise in many science and engineering fields. Emphasising the notion that most rural people are forced to become their own veterinarian, he continued, "You can't get vets to come out for one or two animals. They just won't do it anymore. Now you have to haul the cows to the vet." Also, Patrick elaborated on his command of animal behaviour learned over many years. He described a furtive mare that would not birth a colt in his presence. He no longer expects to see livestock give birth noting that horses and cows will go to great lengths to deliver in private.

The interview revealed that use of native science concepts and skills can be generalised to new situations. This notion is particularly important if gifted high school students are expected to transition to university science classrooms and laboratories. Two years ago, Patrick decided to place a water source in a remote pasture for his cattle. Historically, few options were available to ranchers. They could haul water from another source (an expensive and time consuming option) or erect windmills to convert the abundant wind into mechanical energy lifting underground water to the surface. After much consideration, the Wallaces decided on a third, twenty-first century approach; they purchased two solar panels with complementary equipment and pump. After the water well was drilled and a few technical problems resolved, Patrick erected the panels, placed the pump, and completed all electrical circuits. The pump continues to work without problem despite the project being his first exposure to solar technology. When asked about how he was able to complete the complex bit of engineering, Patrick simply shrugged. He was able to confidently synthesise past experiences including knowledge of plumbing, electricity, hydrology, and even his command of ordinal directions to complete the construction of the solar pump. Since help from the outside was not an option, Patrick's life time of experience informed his decision to tackle and solve the problem of access to water using a high-tech solution.

Skills developed during youth are retained and used in new contexts. When asked if they remembered other stories relating to science and engineering, Robin told a story about how isolation affected how children entertained themselves. As a young girl with few local friends, she had fond memories of diagramming floor plans of imaginary houses. She stated that she still enjoys the process of laying out living spaces and visualising what household items would fit. Modestly, Robin shared that the interior of the home where this interview was conducted was a product of her imagination.

Much of the work that occurs on a working ranch is routine – feeding livestock, mending fences, and maintaining equipment. These routines are punctuated with intermittent problems that demand attention. Patrick and Robin accept machinery break-downs and animals becoming sick as part of their rural existence. Using personal stories, the Wallaces divided problems that they encountered into two categories – those that required immediate attention and responses to challenges that made rural existence easier. How rural residents approach problems offers insights into their role of native scientists. In response to these tests, Patrick and Robin follow similar processes of inquiry and problem solving commonly found in scientific laboratories. When confronted with a problem, the rural scientist assesses the situation and determines what is already known; the native scientist brings to bear all experiences and resources. They engage in extensive planning and gather tools and materials necessary to address the problem-at-hand. More than simple trial and error, the native scientist attempts to control a single variable at a time while implementing their plan. And finally, they assess outcomes and refine their process and product.

Creativity is always in play when confronting problems in a rural setting. The Wallaces used the term "inventive" often and interchangeably with creativity describing their work and the work of others. Patrick recounted a story about a family known in the community for approaching problems with a different perspective. He shared that the design of the neighbour's barn allowed more efficient loading and unloading materials, and that the children were "artistic" and were able to build their own toys to scale. Also, Patrick stated that the family modified common tools so that their work was less difficult. The family established a reputation among members of the tightly-knit community sincecreativity, like independence and persistence, are valued traits that are nurtured in rural homes. Robin shared an example that illustrated how children may be taught lessons dealing with personality traits. She recalled an instance when her neighbour told their son to remove the hydraulic system from a stalled tractor. When the boy replied, "I don't know how," the father told the boy, "You will figure it out" and drove away.

The Wallaces shared other stories about their own children (both attended college and became educators) and rural neighbours who made the transition to university settings. Many of the neighbouring children pursued careers in science, agriculture, and engineering. Patrick and Robin linked children's ability to succeed at the university with three inter-related conditions. They believe: 1) supportive parents and teachers are essential to children's success; 2) bright, "inventive" rural children are more likely to adapt to university life; and 3) strong connections exist between rural life and science content and pedagogies (inquiry, problem-solving, and research).

Adaptability, especially in a social context, is not considered a strength of rural children. The Wallaces cited university lecture-style classes as particularly problematic for rural children's transition to higher education. Many rural students have not been in classrooms with more than ten children. Teachers were attentive and addressed needs of individuals. The delivery of content in rural schools is contextualised and high interest. However, many university science courses are delivered in enormous lecture halls and university instructors rarely ask children what they know, but rather tell students what they must learn. Thus, the support systems found in rural schools are absent or not readily apparent in higher education. Therefore, Rural students migrate towards programs offering familiar systems that cultivate communities that resemble their rural support structures such as-agriculture. wildlife biology, and archaeology.

Despite the complexities and challenges associated with rural living, concepts associated with giftedness and native science do intersect. Nachtigal (1985) examined traits closely linked to rural life and his work supports assertions made in the Wallace interview. Nachtigal found that rurality was bound with tightly-linked personal relationships; broad understanding of one's environment; strong verbal communication skills; time measured by seasons of the year; entrepreneurship; responsive to the environment; and self-sufficiency. Although Nachtigal's rural qualities are generalisations, each represents individual and social tendencies shaped by isolation and each quality is easily transferable to a scientific setting and, ultimately, to a STEM career with the proper tutelage.

TRANSITION TO DIFFERENT SPACES

In order for students to be successful in their transition from high school to university settings (regardless of their career paths), they must believe that the challenges ahead will lead to a positive outcome and they must engage in the effort with a degree of self-efficacy or confidence. Dees (2006) likens the transition from rural school to a university campus to a shift in culture stating that,

> … when the dominant culture, represented in this study as the college classroom, presents ideas that conflict with the students' home culture, an added sense of stress is created in the students' lives. These student "immigrants" are forced to make very difficult choices: adopt the ideas of the dominant culture, deny these ideas, or negotiate some other form of cultural adjustment. (p. 2)

Rural gifted students encounter a high degree of dissonance associated with their home culture and that of any university campus. Survival and success depends largely upon students' ability to adapt, make friends and trustworthy contacts, and develop a new sense of place. Failure to make these difficult accommodations results in a perception of failure and possibly an early departure for more familiar environs. In an attempt to reduce early drop-outs, most universities have established "freshman seminars", early alert programs, or other types of orientation for incoming students (National Resource Center for First year Experience and Students in Transition, 2006). Institutions of higher education design these induction programs based on extensive research in the area of college readiness. Despite the care afforded to transition programs, little attention is paid to the backgrounds of incoming students (Gentry, 2001). Some institutions do acknowledge and track "first generation" college students, but the transition from high school to higher education is unidirectional. Universities' expectations are that gifted students change and adapt to the new academic setting and little attention is paid to students' rural legacy. Typically, admission offices' only required information are high school transcripts and standardised test scores. Higher education's failure to engage gifted rural students has contributed to low numbers of college graduates in rural areas. Only 17 per cent of rural adults age 25 and older had completed college in 2000, half the percentage of urban adults (Whitner & McGranahan, 2003).

A Place-Conscious Transition Model

Unequipped, unaware, or unwilling to capitalise on rural children's native scientific skills, public schools need assistance in identification of gifted students, affirming their abilities, providing enriching experiences, and transitioning to STEM-oriented career paths; higher education appears ill equipped to help rural gifted students transition to their campuses. Few models exist that focus on native science, innate creativity, and the process of nurturing gifted children living in rural areas. The following four-part theoretical framework edifies rural students' potential focusing on areas of independence, problem-solving, and persistence while offering prescriptions that maximise opportunities in science and mathematics-related careers. Subsumed under each area are activities that contribute to rural gifted students' movement toward STEM-oriented careers.

- *Affirmation* – acknowledgement of useful and valued abilities in native rural scientists;
- *Enrichment* – development of partnerships that expand experiences and help reframe students' self images that include pathways to STEM careers;
- *Early Induction* – involvement in supervised, extended, hands-on experiences outside the rural environment; and
- *Mentorship* – participation in practical, long-term, career-specific work under tutelage of trained mentors in science.

Each part of the theoretical framework addresses a place-specific need linked with rural education. Based on a meta-analysis of results from multiple sources, students participating in programs that employ these four components will gain confidence and self-efficacy, develop new science-based knowledge and skills, transition more smoothly to higher education, and view STEM as a viable career option.

Affirmation

Affirmation is the intentional acknowledgement of other individual's or group's skills, knowledge, achievement or position. Marzano (2003) identifies affirmation as a critical ingredient for the smooth operation of healthy schools; Redding and Walberg (2012) believe that the interplay of affirmation and positive feedback, goal-setting, and persistence is a positivemix for rural learners. For gifted rural children, affirmation is particularly important for bridging one's history and belief system with future aspirations. "Affirmations are positive statements that fortify and strengthen us to achieve our goals. They are personally reinforcing, energising and self-motivating. Affirmations help correct negative concepts we have developed about ourselves, depending on our life experiences."(p. 8) (Mayland Community College). Theorists warn that transition from "less valued" or subordinate cultures to competitive settings can result in loss or distortion of identity (Lawrence, 2009; hooks, 2002). Rural children need confirmation that they have value and can succeed in an unfamiliar, academic environment. The process of affirming indigenous science should begin in public schools. Rural school culture must celebrate indigenous skills and information that rural children bring to class. This early affirmation is context for extending rural skills beyond local spaces. The outside culture's understanding that skills possessed by rural children are relevant and transferable to a broader context appear to be a barrier to higher education for rural children. Implications for gifted rural students entering science-intensive college programs are clear. In Hardre's extensive review of rural education, she observes, "Students with more positive motivational profiles in a particular subject area (high perceived ability, instrumentality, learning goals and success expectations) are more likely to take courses in that area and to choose related college majors and career paths" (p. 3).

Research regarding university affirmation of students with native science is limited. Some lessons about affirmation may be learned from members of the agricultural community. Agriculture programs thrive at community colleges, regional comprehensive universities, and primary research institutions positioned adjacent to rural areas. Students recognise course language and equipment in introductory courses and can relate to the credentials and backgrounds of agriculture professors. Agriculture instructors share stories about their own experiences that parallel those of the students in the class. Through familiarity and affinity for the content, students experience tacit affirmation in nearly every lecture. Like traditional STEM programs, agriculture programs are science intensive, yet few perceived barriers to success appear to exist for students with rural origins. In contrast, rural students may be unable to see connections between their life experiences, science content, and other science faculty.

In order to become an attractive alternative to agriculture, science faculty need to be aggressive in their attempts to recruit gifted students from rural areas. Dees (2006) stresses the need for higher education to be more responses to student needs. He posits:

> However, if we, as university educators, practice careful reflection of our own attitudes and values regarding rural/Appalachian students, we may identify strategies that will serve to reframe our own classroom practices. In this manner, we can help our students grow and adjust in meaningful ways. Additionally, we, ourselves, can learn from our students as we co-construct realities and practices that can help to reduce the acculturative stress that is created through the educational experience. (p. 11)

Curricula and instructional change with some emphasis on students' indigenous science knowledge can make a difference. Some institutions have developed complementary, interdisciplinary, science-intensive degrees that appeal to rural gifted students. Wildlife biology, informal science education, and food sciences have found niches at institutions serving rural communities. These science-intensive programs are high interest and affirm student prior knowledge.

Enrichment

In order for gifted students to reach their potential, educational enrichment must begin in elementary schools with increased emphasis at the middle and high schools. Public school educators must do more than simply provide additional content to gifted students; the gifted must have opportunities to explore concepts in greater depth and breadth. Although content is important, modern interpretations of what scientists and engineers do include communicating, collaborating, questioning, and thinking critically and creatively (Soto, 2009). Gifted rural education in science should mirror these values. Using Renzulli's Triad Model (1977), schools must design complementary science and mathematics curricula that challenge gifted students, bolster interest, and make clear connections with rural living.

Again, the literature base for integration of gifted education enrichment, STEM careers, and rural education is somewhat scarce and sometimes contradictory. The National Research Council (NRC) issued an extensive report detailing characteristics of successful STEM schools (2011). The Council outlined goals for STEM-based education and included a unifying theme for STEM schools in the United States. Criteria for STEM-based schools are rigorous curriculum that deepens STEM learning over time, more instructional time devoted to STEM, more resources available to teach STEM, and teachers who are more prepared to teach in the STEM disciplines (p. 7). The report did state that STEM schools target gifted students, but admits that no research indicates that investment into to this population results in STEM majors, related careers, or that graduates from STEM schools contribute to the fields of technology or science more than traditional schools. Using a case study format, the NRC document described select schools where some research is on-going and does attempt to better explain transitions from high school, university, and career. The select schools were all urban; the report did not contain any reference to rural communities, but cited educational inequities that are present across districts and states. It should be noted that most discussion of inequities dealt with structural factors such as facilities, supplies and credentialed or certified teachers. The report proposed five recommendations for improving STEM education. The recommendations reflected the Council's priorities citing content knowledge, qualified teachers, and school organisation with little emphasis placed on nature of students or their learning.

Thoughtful, research-based, student centred examples of enrichment do exist. In a recent grant-funded effort, the Department of Biological Sciences at San Jose State University engaged in a comprehensive reform to prepare incoming freshmen for the rigours of academic studies in biology while acculturating scientists-in-training to professional expectations (Soto, 2009). The biology faculty broach these issues using two strategies: 1) ongoing conversations regarding biology program expectations with high schools and community colleges; and 2) inclusion of enriched, innovative curricula and andralogically sound experiences for students in their introductory biology courses. The university faculty worked directly with their pre-university counterparts. Although much of the university-school interaction focused on meeting admission requirements and articulation agreements, information was shared regarding academics with the goals that incoming university students are better informed and better prepare for higher education science. With an emphasis on enrichment, San Jose State University has added a new component to their introductory biology course sequence that assists students in their transition to college-level science while building community among students. The biology department added an "activities" requirement to their two-course sequence for freshmen. This second laboratory incorporates hands-on activities, field experiences, simulations, problem-solving, and poster-style presentations – all while students work together in small groups. Early indicators show increases in student satisfaction and self-efficacy (Everhart, 2012). More than eighty per cent of students report that they feel that the introductory courses reinforced their goals of working in a biology-oriented career (medicine, research, veterinary science). Opportunities to work in small collaborative groups seem to counterbalance the more traditional impersonal lectures found on most college campuses. The formation of community has resulted in development of impromptu study groups and student-led use of social media to complement introductory biology courses. Although San Jose State University is an urban institution, development of community among entry-level students appears to help students acclimate to less familiar, more academically rigorous setting. Successes at San Jose State University can be adapted to better meet the needs of college-bound, gifted students in rural areas.

Early Induction

Induction is a process of re-orientation, typically moving from familiar to unfamiliar circumstances. In the case of gifted rural students, induction processes are particularly important; they may serve as invitation to succeed, permission to pursue long-term goals, and a means to build self-efficacy. Cook (2007) states that in-bound college students make up their minds quickly regarding whether they can or cannot adapt to new academic, social, and psychological challenges; historically, students withdraw from classes after the first six to eight weeks. Cook describes a well-constructed, early induction process that consists of three distinct parts:

- Separation (removal from former habits and habitat);
- Transition (learning behaviours appropriate to a new circumstance); and
- Incorporation (acceptance into a new society) (p. 7).

Since their commitment to place is strong, and rural gifted students may encounter a barrage of challenges upon during their first weeks on a university campus, induction processes should begin early. When possible, gifted high school students should physically visit college campuses. With the support of secondary school teachers, counsellors, and university personnel, students should build relationships with campuses of interest. Although campus activities such as science fairs and field experiences are memorable and viewed by college recruitment offices as effective tools, these activities are brief and may do little to get students to view themselves as scientists. Extended, structured experiences are necessary for lasting impressions and student ownership of science as a profession. As soon as middle school and high school students begin to view themselves as scientists, the more likely they will pursue careers in biology, physics, chemistry, and geology. Extended-stay opportunities as summer institutes and camps are more likely to meet Cook's induction criteria of "learning behaviours appropriate to a new circumstance" (p. 7). Campuses appear much friendlier places for visiting high school students during summer months. Issues associated with residential housing are eased after full-time students return home for summer. Funding, another possible impediment, may be less problematic because grants and external funding sources are supportive of many university summer programs for high school students. Other facilities such as laboratories and classrooms are less crowded and faculty's schedules are more flexible are accommodating.

Well-planned camps and summer institutes for pre-college students can positively impact cognitive and affective domains of learning. The curriculum for a summer camp should help establish connections with rural science, incorporate high interest science-oriented activities, and build student confidence that a university setting is less threatening and an environment that allows exploration.

Table 1. Sample activities

	Cognitive Domain "Think like a scientist"		*Affective Domain "Feel like a scientist"*	
Exploratory Cue/Activity	Contextualisation	Knowledge/ Skills Development	Behavior	Self-efficacy
In teams of three, build a structure made from simple materials that will support a five kilogram mass.	Rural storage buildings; barns; erection of farm equipment	Materials science; struts and beams, measurement; preparation of oral presentation; control variables;	Succeed as a team; collaborate; consider alternative approaches and opinions; improve structures at home.	Speak publicly about the research
Working in pairs, sort organisms by genotype and phenotype.	Rural fair animal competitions; purchasing and selling animals and crops for profit	Genetics; organismal classification; scientific systems; development of a poster	Share responsibilities; learn information related to animal purchases and sales.	Develop professional standards to share written information

Current efforts to initiate the induction process while students are in public schools are uneven and some activities may even dissuade gifted students from pursuit of careers in science. A recent trend in the United States is encouragement of bright, college-bound children to enrol in dual-enrolment programs. After students meet state high school requirements in language arts, mathematics, social studies, and science, they may take college courses that meet requirements for general education and for some majors. High school students either take these dual- enrolment courses on the college campus, using instructional television, or online. Since distances between rural high schools and universities prohibit face-to-face instruction, rural students' first introduction to a university science course may be relegated to sitting at a computer engaged in reading and low-level thinking. This form of learning reinforces the notions that science is a passive act and that university science is different from the native science experienced by rural children. Induction efforts must re-affirm student experiences and better represent a modern interpretation of careers in science.

Mentoring

Mentoring is a highly effective technique used to influence professional and personal attitudes, processes and techniques, and career paths of novices. Mentorship can be misunderstood and is often confused with internship, apprenticeship, and coaching. Mentorship is a time-intensive, comprehensive act dependent on mutual trust and respect between an expert and novice. Mentorship is an intentional act and the mentoring relationship is a venue for transmission of work habits, processes, skills, content knowledge, and professional ethics/standards. In a recent study, scientists serving as mentors to undergraduate researchers failed to agree on a definition of mentorship (Everhart, 2011). Only after two years in the program did scientists shift their primary mentorship emphases from content and laboratory techniques to modelling, networking, collaboration, and professional standards. Fine tuning mentorship skills happens over time and through extensive reflection and discussion.

Rural students need committed mentors after admittance to a university. More than academic advisors, science faculty may become “loco parentis” and serve as the rural students’ point-of-contact and advocate similar to the adult figures that maintained a influential role in students’ lives on the farm or ranch. The social support for incoming students can be as important to their success as the academic support (Martinez & Klopott, n.d.). Sambunjak, Straus, and Marusic (2010) provided an extensive review of qualitative research that deal with mentoring in the field of academic medicine. They found three dimensions of desirable characteristics among mentors – personal, relational, and professional. Subsumed in these dimensions are several characteristics particularly relevant for gifted mentees transitioning from rural environs to a university science department: altruistic, understanding, patient, responsive, nonjudgmental, motivator, accessible, able to identify potential strengths in mentees, and able to assist students in defining and reaching goals. These characteristics mimic familiar elements of rural students’ home support system and fill in gaps that may occur for students on campus.

Rural Scientists

Although some rural students that acquire advanced degrees in science and math will strike out destinations more commensurate with their field of study, most students show preference for occupations that return them to rural locales (North Carolina State University, n.d.). Bonds with rural communities are strong. Failure to accept the desire to return to rural living could relegate forty per cent of gifted students in the United States incompatible with STEM-related jobs. Acceptance and integration of native science acquired during formative years by high school and university instructors may be the best recruitment tool for science programs. Universities must establish comprehensive transition programs for gifted rural students to meet their social, emotional, and psychological needs. Through affirmation, enrichment, early induction, and strong mentorship, students will reach their potential – unburdening them from any ill effects of space while capitalising upon its many benefits.

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