Improving Students' Mineral and Rock Identification Skills Through Service-Learning

Josphine Chaumba[1] *and Jeff Chaumba*[2]
[1]*Department of Social Work and Communication Disorders, Tarleton State University - Fort Worth*
[2]*Department of Geology and Geography, University of North Carolina at Pembroke*

ABSTRACT

This paper reports on a service-learning component introduced in an upper-level undergraduate geology course. Students identified rock types used by a local countertop manufacturing company and made fliers describing their mode of formation. Students then completed a final rock identification exam. To assess the effect of participating in the service-learning on students' rock-identification abilities, an Independent Samples t-test was used to compare scores of students that completed the course to those from previous semesters who did not participate in service-learning. Students who participated in service-learning achieved higher final rock identification exam test scores (M = 91.71, SD = 1.59) in comparison to those who did not take part in any service-learning activity (M = 80.36, SD = 1.88), t (19) = 4.59, p < .05. Service-learning projects that involve local geology related industries, thus, can facilitate knowledge sharing between the University and the community.

Keywords: geology; community outreach; identifying minerals and rocks

1. INTRODUCTION

Active learning is composed of short course-related individual or small-group activities that are conducted by all students in a class which alternates with instructor-led intervals whereby student responses are processed and new information is presented (Felder & Brent, 2009). Field-based learning, which forms part of active learning, is an integral component of Minerals and Rocks, an upper-level undergraduate class required for all Geology majors at our University and has been taught by one of us since the fall 2013 semester.

1.1 Selection of the service-learning project

After asking students in Minerals and Rocks class to list uses of minerals and rocks they knew prior to their service-learning experience, most listed the familiar uses such as jewelry, monetary reserves, and in construction, for example, but none listed countertops as a possible use. Some studies have concluded that a course-specific tutor-training curriculum advances the participants' knowledge and skills in tutoring and content knowledge gains for pre-service teachers engaged in service-learning (Miller, Yen, & Merino, 2002; Waltz, 2019). For this service-learning project, teacher preparedness was achieved through review of the literature and our knowledge and experience of the local geology.

1.2 Purpose

Incorporating a community component to this class is to cater for active learning as employing a variety of teaching styles has been recommended as the best teaching practice (Romanelli et al., 2009). Well-prepared lectures often do not engage all students when the composition of the students is multicultural as cultural influences on learning style preferences warrant instructional approaches that can cater for culturally heterogeneous students (De Vita, 2001). Service-learning is one way of employing a variety of teaching modalities to deliver instruction. Even well-prepared lectures may not engage all students all of the time. Students have different learning style preferences, for example based on cultural influences (Holtbrügge & Mohr, 2010), which may inhibit learning in a traditional lecture-based course. In a multicultural classroom, it is especially important to use a variety of teaching styles to enhance learning for all students. In our class, we developed a service-learning project with a nearby geology-related industry.

Our goal of incorporating service-learning into this course was to evaluate its effect on students' performance through more hands-on study of rock specimens in comparison to two cohorts who had previously taken the same class but did not participate in any service-learning activities. Further, we also decided to participate in a service- learning project to respond to the call by our University to increase community engagement although it is not required for graduation. Students who took the Minerals and Rocks class during the fall 2017 semester consisted of a single African American male student, a single mixed-race male student, and six White male and female students (Table 1). Students who typically enroll in this course, which is offered once every two years, are juniors and seniors.

Opportunities for field work for our students are limited, since our four-year University is located on the Coastal Plain which lacks rock outcrops. A countertops manufacturing company (Figure 1) within a

Table 1. *Summary of the Total Number of Students, Pre-Test, Student Races, Lab Pre-Test and Lab Final Exam Scores and During the Four Semesters of Teaching the Minerals and Rocks Class*

	Fall 2013	Fall 2015	Fall 2017	Fall 2019
Number of students	11	8	7	6
Average Pre-test score	79.2±6.18	79.4±7.96	80.6±4.28	80.6±4.28
Average Final exam score	80.4±6.23	83.4±11.87	91.8±5.95	91.8±5.95
White	6	6	7	3
Black	3	2	0	1
Native American/Hispanic	2	0	0	2

Figure 1. *(a) Technicians Cutting Countertops Inside the Workshop in October 2017 (b) A Huge Saw Used for Cutting Some of the Rock Slabs*

couple of hours drive away provided a great service-learning opportunity for our students. Our own desire to find placements for our students where they can do internships and thereby increase probable future employment opportunities for our students, also contributed to our introduction of the service-learning component in this class. Such internships can enhance students' knowledge about applied aspects of rocks that are useful in the countertops industry but are not taught in the normal geology curriculum.

2. LITERATURE REVIEW

2.1 Service-learning overview and relevancy to geology

Service-learning can be defined as a teaching technique that permits students to combine academic curriculum with community engagement and outreach (Esson & Stevens-Truss, 2005). Service-learning can help students to develop professional skills and it can also be linked to academic learning objectives such as face-to-face interaction, technological/scientific consulting, grant writing, assessments, and research (Szymanski, 2016). Service-learning experiences help to improve social skills of students that are important to prospective employers, and the community also benefits from service-learning through new ideas and knowledge (Silka, 2016). One of the most important aspects of service-learning is the skills gap it covers which traditional course-work may not provide, such as teamwork skills and hands-on experience, respect and acknowledgement of contributions from others, and the opportunity to adapt and apply appropriate technology (Crawford et al., 2011).

As University-community partnerships evolve and improve (Pasque et al., 2005), there is an increasing recognition of the importance of forging 'mutually beneficial knowledge exchange relationships' where universities and communities learn from each other to promote development and sustainability (Mukuria & Sydes, 2014). One way to achieve these partnerships is through service-learning projects completed by University students and faculty with a community partner, helping students apply what they learn in college to solving real world issues. Existing hands-on experiences in our class involve mineral and rock identification of hand specimens and under the petrographic microscope. Service-learning can be a complex practice for a novice instructor to implement as educators must provide support and a realistic vision for implementing service-learning in order to achieve effective and consistent use of service-learning in future classrooms. The manner in which educators are prepared and supported on the job typically falls short of developing the capacities they need to evoke change (Smylie, Bay, & Tozer, 1999). Teacher education programs, for example, fail to reproduce environments similar to those faced by teachers when they graduate (Farrell, 2009), as well as lesson planning and delivery, classroom management, and identity development (Farrell, 2012).

The average American is likely to have learned very little about geology prior to joining the workforce due to limited exposure to geologists and geological applications in everyday life. For instance, at the pre-kindergarten and kindergarten levels, only 2-3 % of teachers have highest degree in the geosciences, which further decreases to 1-2 % in elementary school (American Geological Institute, 2010; Wilson, 2016). The National Science Education Standards recommend field trips for K-8 science curriculum as field trips enhance the student learning experience (National Research Council, 1996).

In high school, only ~3 % of teachers in the fields of computer science, math, and science have highest degree in the geosciences yet requirements for earth science education should be met by most students in middle school (grades 6-8) (American Geological Institute, 2010). In the US, only 6 states require Earth and Space Science for high school graduation (Center for Geoscience Education and Public Understanding, 2013) which also contributes to fewer earth science teachers in comparison to other related disciplines. Consequently, geoscience undergraduate programs record lower enrollments compared to other sciences (Holbrook, 1997). Gonzales and Keane (2011) observed that 91-94 % of high school students receive instruction in biology in high school compared with only <25% who do so in earth science. No background knowledge is assumed in our incoming freshmen as the learning experiences of earth science are considered to be of less rigor and substance than other STEM fields (Hoffman & Barstow, 2007; Schaffer, 2012). It is not surprising, therefore, that in any earth science-related job which does not require an undergraduate geology degree, the majority of the employees at any earth science-related industry most likely lack even the basic knowledge of what their jobs may require of them (Van Loon, 2002). To compound the problems, although numerous earth science-related service-learning activities are conducted to K-12 students (Hansen and Fortner, 2016), many of them are only available as conference abstracts. Having teachers with specific area content in K-12 curriculum, however, would likely involve implementation content-area specific teacher technology preparation with faculty support to learn, motivation, and opportunities (Dexter, Doering, & Riedel, 2006).

2.2 The role of service-learning in undergraduate learning experience

Higher education has long been encouraged to educate students for a life as responsible citizens, rather than educating them solely for a career (Boyer, 1994). By engaging in service-learning students are able to connect theory to practice in order to meet challenging social problems (Boyer, 1994). Emphasizing service potentially enriches learning and promotes the dignity to the scholarship of service. Students who engaged in service-learning record higher course grades and are significantly more likely to perform up to their potential more than those who did not (Markus et al., 1993). Additionally, students who participated in service-learning developed a greater awareness of societal problems and apply principles from such courses to new situations (Markus et al., 1993). Yue and Hart (2017) analyzed data from 31,074 undergraduates from a western US University who participated in service-learning from fall 2002 to fall 2009 and concluded that it had a significant positive relationship with graduation for both first-time freshmen and transfer students.

The field of teacher education has long valued the role of experience in developing future teachers and it is through such practice experiences that pre-service teachers can define their strategies to produce critical connections between theory and application (Zeichner, 2010).

Campus-wide commitments to service-learning are developed through emphasis in courses and professional development opportunities for faculty (Bates et al., 2009). Our University also provides similar opportunities which helped our preparedness for service-learning, in addition to our own review of the literature. An increase in students entering college is molded by advances in technology, as well as increasing class sizes, warrant the use of different styles of teaching such as incorporating service-learning (Romanelli et al., 2009).

3. PURPOSE AND DEVELOPMENT OF THE SERVICE-LEARNING PROJECT

3.1 Background

Our service-learning project was predominantly focused on studying the different rock types used at the countertops company and making fliers for use by the company employees in rock identification. Our objective was to enhance our students' learning experience of rocks that are used to manufacture countertops through visiting the company, collecting specimens for study in class to enhance students' rock identification techniques, and producing fliers with rock names, their mineralogy, and brief descriptions of their possible modes of formation. Our motive was to help students and the community partner employees identify and understand how these rocks were likely formed.

3.2 Mutual benefits of service-learning project to community partner and University

This service-learning project was also of benefit to the community partner because research suggests that most technicians in hard rock related industries receive their experience through on the job training and may not have any formal training in geology (Voynick, 1978; Samuel & Fors, 2004; Yates, Williams, & Dujardin, 2005). The goal of making fliers for the technicians was just to enhance their knowledge of the different rock types they work with in case clients request specific rock types. Knowledge of individual rock types, however, is not critical for the company operations as their clients typically select countertops of their choice based on available stock.

Faculty also benefit from this countertops company as it provides us with free polished rock samples that can be used for teaching purposes, as well as enriching our Department's rock sample collection. With very few published works on service-learning in the geosciences (Field et al., 2003), and almost no peer-reviewed articles available on University-geosciences related service-learning programs, particularly in our region, it is hoped that this work might spur similar service-learning projects here and elsewhere.

4. METHODOLOGY

All students in our Minerals and Rocks class take the same mineral and rock identification pre-test composed of 12 common rock specimens on the first day of our laboratory. However, different (and rarer) specimens, but of the same rock types, are used for the final examination. The fall 2017 semester was the first that our students participated in this service-learning component at the countertops company. Students who enrolled in this class in the fall 2013 and fall 2015 semesters did not participated in any service learning, and those who participated in the service-learning project (fall 2017 and fall 2019 semesters) did not have internships at the company. Each student in the fall 2017 and fall 2019 semester classes had to choose one rock type for further study in class, different from those selected by others in the class. At the end of the semester, final versions of single-page fliers describing the mineralogy, rock name, and its likely origin, produced by the students, were printed out and mailed to the company by the course instructor so that the technicians would be able to use the sheets to properly identify the rocks. Students in subsequent semesters would continue to identify more rocks and to make more fliers for the countertops company's use as the students' service component. By studying one rock type from the countertops company in detail, the students would engage in "a methodology that extends classroom learning into real-life situations through participation in service experiences organized by collaborating schools and communities" (U.S. National and Community Service Act, 1990, As amended through December 17, 1999, P.L. 106-170, page 5). The countertops company that students visited employs no geologist at its operation, but they agreed to have our students work there during the summer as interns.

5. RESULTS

The final rock identification examination for this course, administered at the end of the semester, includes the same number of, and comparable, samples which represent all the three rock families. Results from students who took the Minerals and Rocks class from fall 2013 to fall 2019 are shown in Table 1. During the period under review, students who took the Minerals and Rocks class ranged from a low of 6 in fall 2019 to a high of 11 students in fall 2013 (Table 1). In the fall 2017 semester, all students were White (4 males and 3 females). In the fall 2019 semester, the class was comprised of 3 White students (2 males and 1 female), 1 African American female student, and 2 Hispanic students (1 female and 1 male) (Table 1). Grades in the fall 2017 and fall 2019 semesters were comparable (Table 1). The lack, and scarcity, of other racial groups besides Whites in all semesters under study precludes conducting a meaningful study of the variations of student performances by race. Consequently, neither differences nor similarities in student performances by racial groups were closely monitored during the period of the study. The improvements in students' final examination scores of all races before and after implementation of service-learning were all comparable.

Students who took part in the service-learning course performed better in the rock identification examination than students from the two previous cohorts that had taken the same course but without a service-learning component (Table 1; Figure 2). Students' final rock identification examination grades ranged from 10-14% higher than those of students who had taken a comparable examination but did not have a service-learning component in their course (Table 1; Figure 2).

Results of an Independent Samples *t*-test calculated to examine if there were any group differences in the scores of students in the class without service-learning versus scores from the class with the service-learning activity. Students in the service-learning class achieved higher scores ($M = 91.71$, $SD = 1.59$) compared to students who did not take part in any service-learning activity ($M = 80.36$, $SD = 1.88$), $t(19) = 4.59$, $p < .05$.

An example of a brief description of each rock in the form of a diagram or cartoon is shown in Figure 3. The rubric for the Assignment included 1 point each for each of the points just described, all on a letter (8.5 × 11 inches) size paper. The wide variety of rock types that are worked with at this countertops company are all subdivided by the company technicians into three names only: granite, marble, and "quartz", although there are in excess of 20 different rock types used.

Figure 2. *Bar Diagram Showing Pre-Test and Final Lab Scores for the Class*

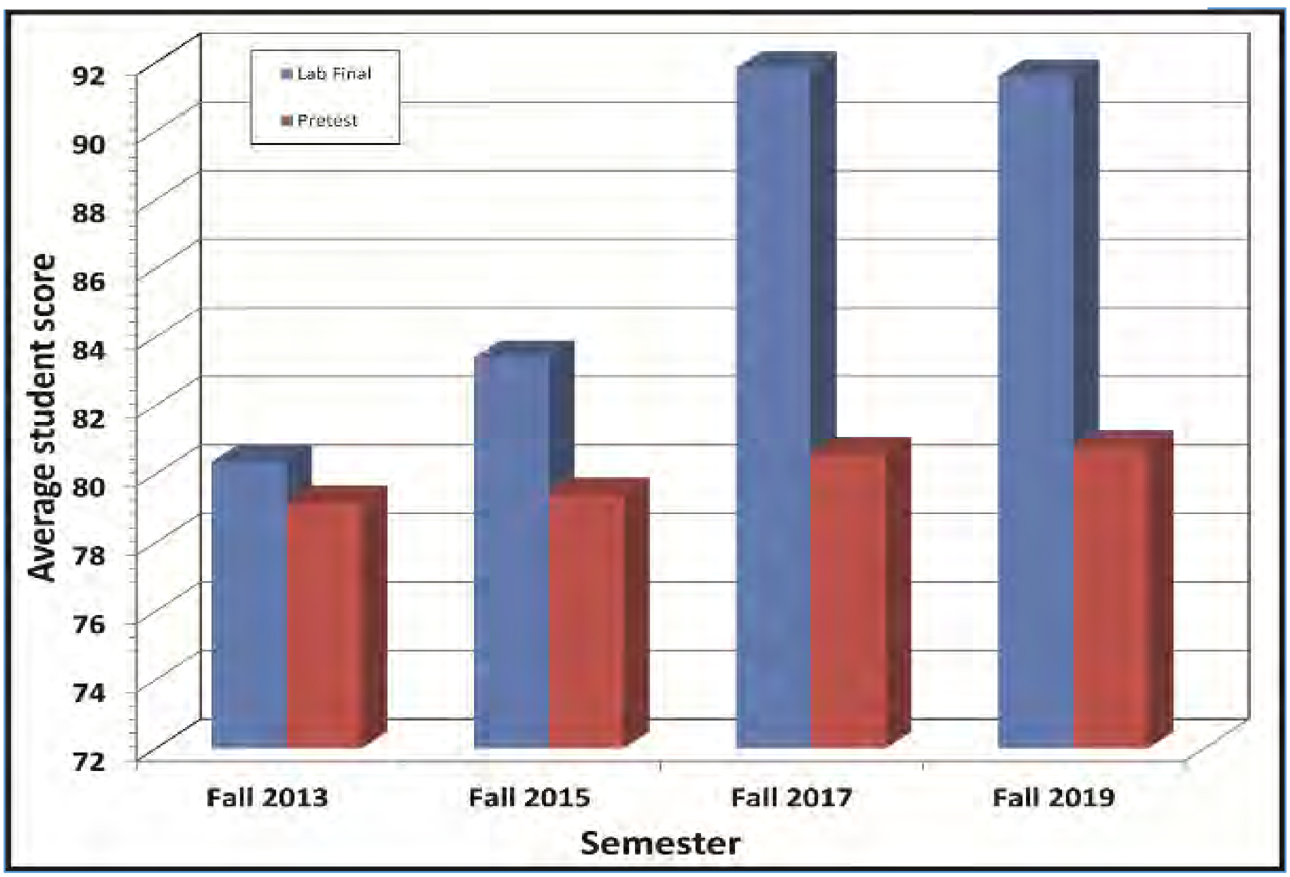


Figure 3. *An Example of Fliers Produced by Students describing the Brazilian charnockite "Green Uba tuba"*

Brazilian charnockite "Green *Uba tuba*"

"**Green *Uba tuba***", or **Brazilian charnockite**, is a fine-grained & dark green rock non-foliated metamorphic imported from Brazil. It is composed of the minerals pyroxene, alkali feldspar and quartz. The dark color in "green *Uba tuba*" (Fig. 1) is due to the minerals pyroxene and, rarely, olivine. Charnockites, sometimes called orthopyroxene granites, are orthopyroxene-bearing quartz and feldspar-rich rocks and commonly form orthogneiss plutons in many metamorphic (granulite) terranes. Most charnockites originated at different settings such as those rich in Fe (ferroan) at rifts, and those rich in Mg (magnesian) at deeply eroded arcs (Fig. 2). Figure 2 is a cartoon illustrating how a charnockite (magnesian granotoid) may be formed at arc settings where an oceanic plate is subducted beneath either another oceanic or continental plate.

Figure 1. Sample of Brazilian charnockite "green *Uba tuba*" at the countertops company.

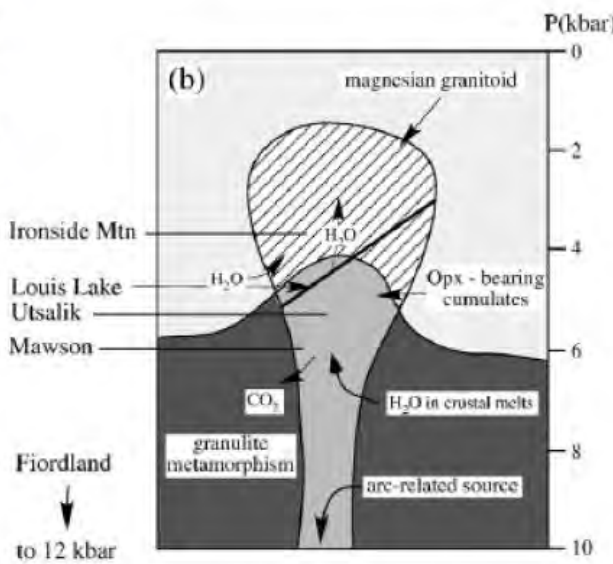


Figure 2. Diagram illustrating the likely formation of a charnockite related to arc magmatism.

6. DISCUSSION

Questions for the pre-test and final rock identification exam, as well as the rock types administered were the same across the four semesters, although the order in which they were asked varied each semester. Part of the limited variation in the pre-test scores for this class probably stems from having the same instructor teaching introductory level geology labs which is the only pre-requisite to the Minerals and Rocks class. The same instructor taught the Minerals and Rocks laboratory since the fall 2013, so any changes in the scores presented are likely to be a consequence of the service-learning component that was introduced. Further, that students worked on their projects for the entire semester probably helped improve the content knowledge of this course. However, the increase noted in the rock identification examination scores from the fall 2013 and the fall 2015 semester (Table 1; Figure 2) may have been due to the instructor having improved on his teaching during the fall 2015 semester in comparison to the fall 2013 semester.

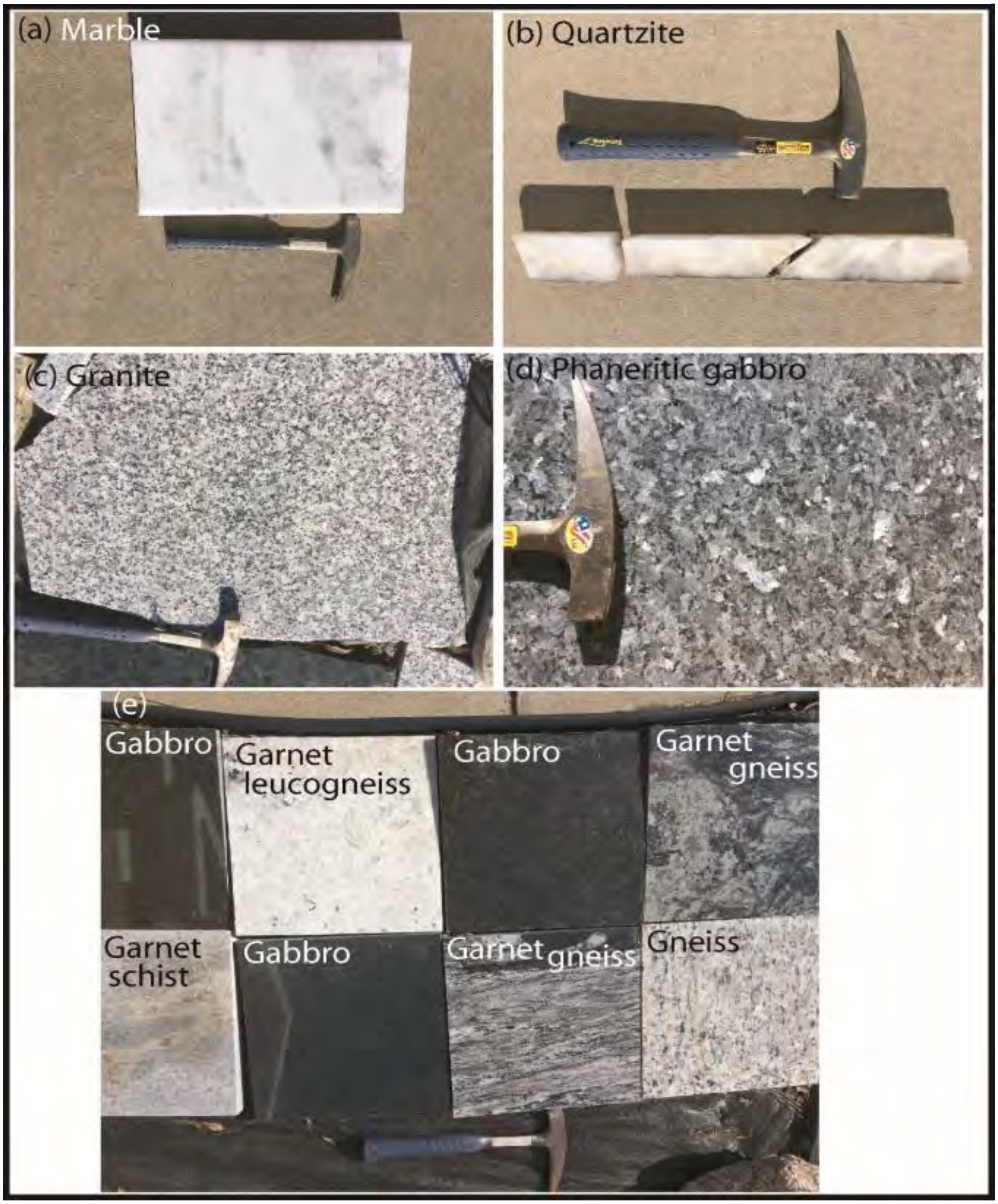
End of semester rock identification exam scores from our service-learning course indicate that students largely benefitted from the service-learning course by performing better than earlier cohorts who did not participate in service-learning. The much-improved final lab exam scores by students who participated in the service-learning project may also be due to their enhanced ability to apply course knowledge to real-world problems (Liu et al., 2004). Results of the Independent Samples *t*-test also suggest that participation in the service-learning activity improved students' mean scores on the final rock identification by >11 points.

Only igneous and metamorphic rocks, the so-called hard rock families, are used to make countertops at the company due to their higher hardness as sedimentary rocks are often soft. The fall 2017 and fall 2019 students who were part of the service-learning classes to the countertops company performed exceptionally well particularly in the hard rock families during their final rock identification examination. Since this course's final rock identification examination scores on the section on sedimentary rocks were similar to those from previous two semesters, we attribute the robust performance by our students on the hard rocks section largely to their participation in the service-learning component. Their exposure to these hard rocks, not only on their rocks of choice but also from their fellow students' choices of hard rocks throughout the semester, may have resulted in students' becoming more familiar with these rocks. Each student had a different hard rock specimen from the rest of the students and had to give an oral presentation of their findings at the end of the semester, ensuring that students' exposure to a wider variety of hard rocks was high throughout the semester. The improved final rock identify-cation examination scores by our students demonstrate that participation in high-quality service-learning can result in increased identification of rocks as evidenced by their test scores (Billig, 2004).

Examples of some rocks used for kitchen countertops cut into small slabs are shown in Figures 4a-e. Granite (Figure 4c) and its metamorphosed equivalents of schists and gneisses (Figure 4e), and other metamorphic rocks, present the greatest challenge for the technicians to identify (Figure 4). Granite is composed of a wide variety of minerals that possess different colors and hardness. Consequently, the metamorphosed varieties of granite and sedimentary rocks are troublesome for the technicians to identify; hence they simply refer to all these rock types as granite. Even other rocks, termed gabbros, that are composed mostly of dark colored minerals (Figures 4d, e) are also misidentified as granite, yet such rocks, besides both being formed from magma, have different colors due to the different proportions of different minerals which formed them.

The performance of students in the cohorts which took part in the service-learning experience is indicative of our students being positively impacted by the community engage-

Figure 4. *Examples of Polished Countertop Blocks Used for Instruction*



Note. Marble (a) and quartzite (b) are the easily identifiable rocks. Granite (c) is often incorrectly applied to other rock types shown in (d) and (e) whose proper names are shown. Geologic hammer is 32 cm long.

ment. This can be interpreted as clear evidence of the impact of service-learning on academic performance (Celio et al., 2011). The company benefitted in having fliers of the common rock types made for them, prompting them to offer internships to our students. The company also provided polished rock samples that we use for teaching and community outreach. Although the countertops company deals with rocks, their operations can continue to thrive without their technicians' ability to identify rocks. However, in situations where some clients who cannot visit the company operations for various reasons (such as during a pandemic) request specific lithologies, a knowledge of lithologies would be beneficial to such a company's employees.

7. CONCLUSIONS

The impact of the involvement of our Minerals and Rocks students in community engagement is reflected in the much-improved scores of our students. Conducting a community service-learning project improved our students learning experience based on higher final rock identification examination scores of students who participated in service-learning in comparison to those from prior semester who did not. The service-learning experience also benefitted our community partner. This service-learning project also helped us improve our sample collection for teaching and outreach.

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AUTHORS' BIOGRAPHIES

Josphine Chaumba, Ph.D., is Associate Professor and Department Head, Tarleton State University – Fort Worth. Her research is in Mixed Methods, Social Capital, and Community Engagement. Department of Social Work and Communication Disorders, Tarleton State University – Fort Worth, 10850 Texan Rider Dr, Crowley, TX 76036, USA. Email: jchaumba@tarleton.edu

Jeff Chaumba, Ph.D., is Associate Professor at University of North Carolina at Pembroke. He is an Igneous and Metamorphic Petrologist, Economic Geologist, and Hydrologist. He is also involved in Outreach. Department of Geology and Geography, University of North Carolina – Pembroke, 1317 Oxendine Science Building, 1 University Dr., Pembroke, NC 28372, USA. Email: jeff.chaumba@uncp.edu