Analysis of the Effectiveness of POGIL on Future Ready Process Skill Development in a High School Biology Classroom

by

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Submitted to the Graduate Faculty of the

School of Education in partial fulfillment

of the requirements for the degree of

Doctor of Education

University of Pittsburgh

2021

UNIVERSITY OF PITTSBURGH

SCHOOL OF EDUCATION

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May 3, 2021

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My problem of practice is that my learners were not learning and growing to their fullest potential in both content and necessary future ready skills – 21st century and process skills to prepare them for postsecondary life outside of my classroom. I teach many high school learners with exceptionalities. I sought to alter my instruction and ensure that learners' learning opportunities were meaningful. My aim was to improve my ability to teach and assess learners' future ready process skills in my high school biology classroom. The specific future ready process skill of focus for this study was interpersonal communication.

In this study, learners were exposed to future ready skills in activities using the POGIL (Process Oriented Guided Inquiry Learning) framework.

Keywords: process skills, 21st century learning, POGIL, biology, high school

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1.0 Naming & Framing the Problem of Practice

My problem of practice is that my learners were not learning and growing to their fullest potential in both content and necessary future ready skills – 21st century and process skills to prepare them for postsecondary life outside of my classroom. I taught many high school learners with exceptionalities. I sought to alter my instruction and ensure that learners' learning opportunities were meaningful. My aim was to improve my ability to teach and assess learners' future ready process skills in my high school biology classroom. The specific future ready process skill of focus for this study was interpersonal communication. Based on review of the literature and interviews with professionals in the field, I do believe there were many influences on my problem of practice as noted in Figure 1.

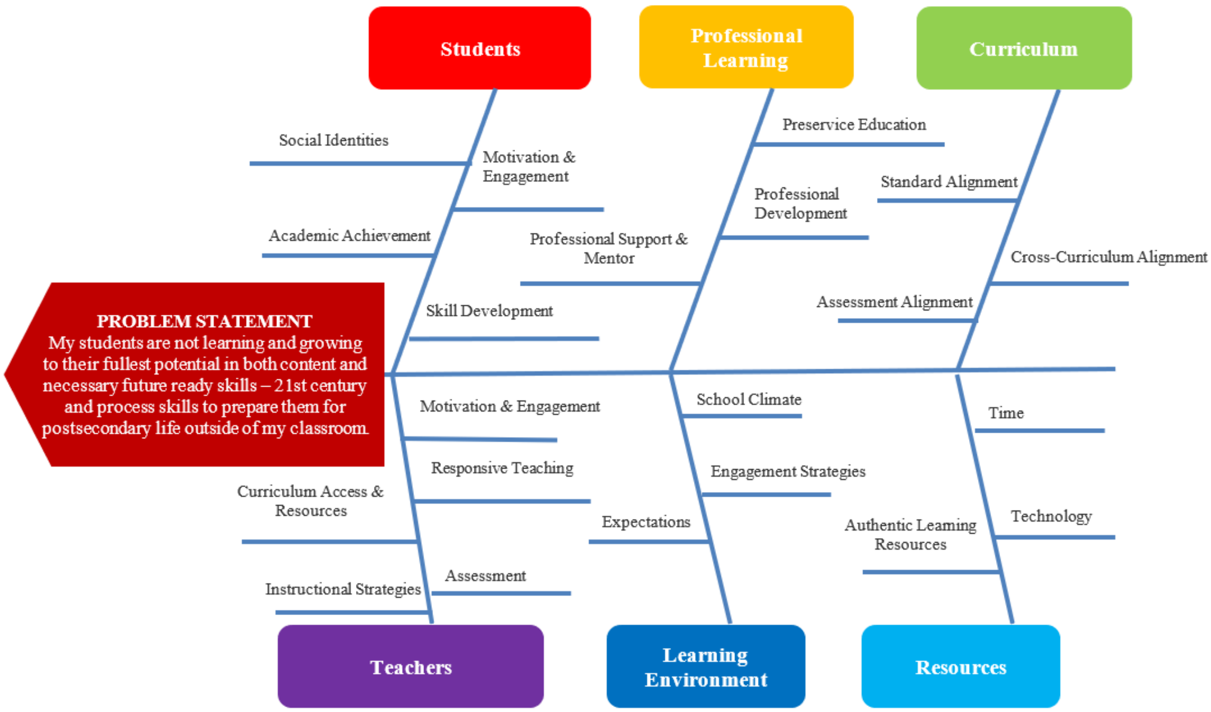

Figure 1. Fishbone of Practice[1]

Relating to those influences, I identified more specific challenge areas within my problem of practice relating to the areas of professional learning, teachers, curriculum, and resources. The first challenge area was finding a unified definition of future ready learning and 21st century skills, which relates to professional learning for teachers as well as resources. The second challenge area was locating appropriate resources on process skills in biology, which relates to resources and teachers. The third and fourth challenge areas were identifying assessment tools for process skills in biology and designing local instructional activities and assessments on future ready process skills in high school biology. The third and fourth challenge areas related to curriculum and

[1] Each portion of the fishbone diagram is an influencing factor on my problem of practice.

teachers. All of the challenge areas were connected to teachers which impacted learners, both directly and indirectly.

1.1 Expanded Problem of Practice Statement

My problem of practice is that my learners were not learning and growing to their fullest potential in both content and necessary future ready skills – 21st century and process skills to prepare them for postsecondary life outside of my classroom. I taught biology to many learners with exceptionalities. I sought to alter my instruction and ensure that learners' learning opportunities are meaningful. I aim to improve my ability to teach and assess learners' future ready-based (science, technology, engineering, arts and mathematics) learning in my high school biology classroom. Complicating matters, I did not have access to instructional tools and assessments that would reveal whether and to what extent learners were learning rich future ready practice. Thus, my teaching cycle of planning, instruction, assessment, and reflection revolved mostly around learners' mastery of biology content material. My classroom was dominated by teacher-led direct instruction and lectures to transmit a large body of scientific knowledge. This general problem was shared by my colleagues in our science department and other professionals in the field (Tanner, 2004; Anderson, 2017) in that we did not consistently use rigorous or responsive instructional strategies or appropriate assessments to increase learners' 21st century skills and future ready competency skills.

Historically, science education has been taught largely by teacher-led lecture with an emphasis on vocabulary words and trivial facts that are typically memorized. Despite the changes in society, industry, and technology, our instructional delivery approaches have remained unchanged as the passive delivery of material information (Rifai, 2018). The narrow, limited, and teacher-centered approaches to future ready curriculum, instruction, and assessment called for a balanced approach to teaching and learning (Quigley, 2016). Research had demonstrated learners need to be actively engaged to have a fuller, deeper, and long-lasting understanding of scientific process skills and concepts (Leonard, 2001/2019).

My problem of practice related to recent statewide and national calls for all PK-12 learners to develop future ready and 21st century process skills, defined by many as adaptability, higher order thinking, non-routine problem solving, self-management/evaluation, scientific argumentation, digital literacy, and engineering habits of mind (systems thinking, creativity, optimism, collaboration, communication, and ethical reasoning) (Duran, 2011; Basham, 2013; Alozie, 2019; Karomah, 2018; Herro, 2017; Dewi, 2019). Others defined necessary skills for learners as: life and career skills, learning and innovation skills, as well as information, media, and technology skills (Assesfa, 2012). There is an understanding that future ready and 21st century skills are critical for learners to be successful, productive, and knowledgeable citizens.

There is a variety of policies that have influenced our classrooms (i.e., Benchmarks for Science Literacy, the National Science Education Standards, The Pennsylvania Science Academic Standards for future ready concepts, the Framework for K-12 Science Education, and the Next Generation Science Standards) and led to a variety of curriculum, instructional, and assessment approaches. These skills and habits of mind are important for increasing learner entry into and success rates in future ready related careers/jobs and for ensuring that the United States will be able to compete in an increasingly diverse global market. Although these goals are widely held as important for learners and our society, individual teachers and groups of teachers do not tend to have access to future ready-focused curriculum, resources, or professional development designed to promote relevant and rigorous future ready learning for all young people.

1.2 Stakeholder Description and Policy Connection

School systems are now collecting more data and focusing on accountability measures than ever before due to No Child Left Behind, Race to the Top, Investing in Innovation Fund, Teacher Incentive Fund, and most recently The Every Learner Succeeds Act (Bryk, 2016). The Every Learner Succeeds Act (ESSA) of 2015 was a reauthorization of the Elementary and Secondary Education Act (ESEA) from 1965. ESSA replaced No Child Left Behind from 2002. ESSA is now the primary law for K-12 education in the United States that regulates state and district level activity through mandates, inducements and system-changing shifts. ESSA does not necessarily prompt capacity-building unless individual teachers or districts take the initiative to invest in capacity-building research and training. Under ESSA, states now have more flexibility in the education plans for their schools. The state framework must include: academic standards (content, career, and eligible content), annual testing (Keystone Exam for Biology, Algebra and Literature), school accountability (Future Ready Index (FRI) for growth and mastery in Keystone Exam areas, AP Exam Achievement, Graduation Rate, and Post-Secondary Achievement), academic achievement goals (FRI and Act 156: Pathways to Graduation), support plans for struggling schools (Support and Improvement Committees), and report cards (FRI and Pennsylvania Value-Added Assessment System (PVAAS)).

Greensburg Salem High School (GSHS) was and currently is directly impacted by all components of the ESSA Framework. GSHS educators are required to cover specific academic standards for each content taught and learners are required to participate in annual testing for the Keystone Biology, Algebra and Literature. The Greensburg Salem School District (GSSD), GSHS and individual educators (depending on area of expertise) receive performance marks on the FRI and PVAAS indicating learner progress toward future ready index goals for all areas in the school accountability and academic achievement goals sections within the framework. In the winter of 2018-2019, GSSD and GSHS were identified for the Additional Targeted Support and Improvement (ATSI) by the Pennsylvania Department of Education for the support plans for struggling schools due to the Future Ready Index indicators.

Within the accountability system (O'Day, 2016) as defined by legislation and the public-school structure under ESSA, there were multiple stakeholders that connect within my place of practice. A stakeholder is defined as any persons, groups of people, or organizations that need to be considered to have a shared interest in the system (Bryson, 2004). The primary stakeholders in any organization serve as the principal beneficiaries to the system change and outcome of the project. While the secondary stakeholders still have a vested interest in the system change and outcome of the project, they are not directly involved in daily classroom work. The secondary stakeholders can be connected to the primary stakeholders in the form of aid. The primary stakeholders that related to my problem of practice were teachers and learners while the secondary stakeholders were administration, families, and employers. Both the primary and secondary stakeholders that related to my problem of practice have minimal influence on legislative requirements relating to public school.

Being that my place of practice and the problem of practice focused on instruction and assessment of future ready learning, I defined the primary stakeholders as the teachers and learners. Furthermore, I was the specific educator stakeholder of focus and my classroom rosters were the learners of focus. The teacher and learners interacted within the classroom with content defined as an instructional unit of study (O'Day, 2016). All aspects of my classroom were influenced by the components of the ESSA framework noted above.

Although the ESSA framework guides standards, eligible content, large-scale assessments, as well as growth and achievement measures, I did have flexibility in the curriculum scope and sequence I followed, the materials I used, and the instructional as well as assessment approaches I implemented in my classroom. The process map featured in Figure 2 highlights the classroom instruction design cycle I used within my classroom.

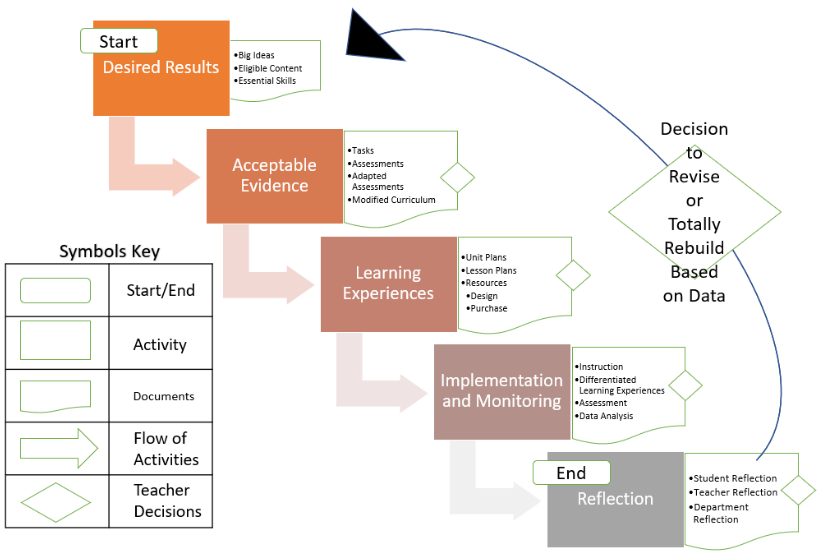

Figure 2. Classroom Instruction Design Cycle[2]

Due to the ESSA framework and accountability structure of the Pennsylvania Department of Education, the classroom instruction design cycle in my classroom began with a focus on planning with the desired results (big ideas, eligible content, and essential skills) in mind. Biology

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[2] The sections in this cycle were impacted by federal, state, and local portions of the ESSA framework.

learners in the GSSD were required to complete the Keystone Biology Exam at the end of my course so the primary aim was to build content knowledge with a secondary aim of essential process skills development. While I focused on planning for instruction, I identified acceptable forms of learning evidence (task completion, unit assessments, adapted assessments for exceptional learners or modified curriculum assessments for learners with extreme learning needs) and built learning experiences based on appropriate pacing and available resources (lesson plans, unit plans, and resource gathering). Once the classroom learning experiences were planned, I worked to implement the instructional activities through differentiated learning experiences and monitored learner learning through formative and summative feedback. The observations and data gathered through assessments allowed for my instruction to change based on professional reflection.

I used the process to ensure I was meeting the requirements of the state accountability system as well as the needs of my individual learners. I will be professionally evaluated based on growth and achievement data in the form of the Pennsylvania Value-Added Assessment System (PVAAS) and Future Ready Index (FRI) numbers at the conclusion of the 2020-2021 school year. As a professional, I aimed to develop a responsive, safe, classroom environment that exposes learners to a wealth of knowledge and skills. To meet the needs of learners as well as my professional commitment to curriculum, I was entrusted to learn and research best instructional and assessment approaches for learning biology along with future ready skills. My learners were required by the Greensburg Salem School District to take and pass Biology and by the state of Pennsylvania to grow and achieve proficient or advanced markings on the Pennsylvania Biology Keystone Exam (PBKE) while also preparing to enter post-secondary life with essential workforce skills. The data for the PVAAS, PBKE, and the FRI will not be available for professional evaluation or reflection until the beginning of the 2021-2022 school year.

The secondary stakeholders relating to my problem of practice were the administrators, families and employers. The administrators assisted in my classroom by supplying the physical resources and learner supports and providing professional development opportunities. The professional development opportunities occurred during the summer of 2019 and during the 2019-2020 school year. The typical classroom observations that would be conducted to observe instruction and provide teacher feedback were not conducted due to the impact of the COVID-19 pandemic. However, administrators frequently reviewed the curriculum materials and resources developed for use in my classroom. Administrators will evaluate my performance as an educator using the Charlotte Danielson Framework for Teaching (CDF). The CDF allows for levels of effectiveness (unsatisfactory, basic, proficient, and distinguished) within broad categories to be noted on my professional record in addition to the PVAAS and FRI data (Bryk, 2016). Administrators will also be evaluated based on the growth and achievement measures of my learners once data is available. Our district and administrators will also be evaluated based on the graduation rate of our learners which will be influenced by whether learners successfully pass my biology course. Families and employers were secondary stakeholders because they assisted learners throughout the schooling process and benefited from the success of learners as they developed the necessary knowledge and skills for post-secondary ventures.

1.3 Positionality of the Researcher

Just as my learners arrive to my classroom with a unique background and demographic, my personal background and experiences impact my professional influence. I am a Caucasian female who received her primary and secondary education within the Greensburg Salem School District. I grew up in a middle-class family and was a first-generation college student who earned a Bachelor of Science in Chemistry and minor in Secondary Education as well as a Master of Science in Instructional Design and Technology from Saint Vincent College. During my student tenure at Greensburg Salem, the student population as well as the professional staff population was not diverse with the majority being Caucasian/White. Saint Vincent College is a private Benedictine college that focuses on ethnic, gender, and geographic diversity. In addition to the curriculum at Saint Vincent College, I also had the opportunity and privilege to travel national and international which allowed for me to experience different cultures. The opportunity to travel national and international was a privileged experience not provided or experienced by all. Returning to the Greensburg community and Greensburg Salem School District shortly after graduation from Saint Vincent College, there was a notable change in socioeconomic status levels (increased poverty) as industry in the area has shifted (increased number of companies in the area have relocated or shut down, increased influx of industry closer to the Pittsburgh area), family structure (increased number of families that are transient), and ethnic/racial demographics (increased diversity). Westmoreland County is an older population pocket in the state of Pennsylvania and Greensburg has been the center for resources that relate to lower socioeconomic status for families and individuals due to closures in other areas of Westmoreland County. I understand and am aware of the roles and responsibilities that surround being an educator in a now increasingly diverse school community. I believe that every child is a unique learner that needs a compassionate, safe and inspiring environment in which to thrive and develop academically, physically, socially and psychologically. Although learners arrive in my classroom with a diverse background and demographics relating to knowledge as well as life experiences, it is critical that each learner has the opportunity to express their knowledge, collaborate with others, and experience instructional methods that allow for feedback and growth. As an educator, it is my desire to assists all learners in reaching their fullest potential, to act as a guide in providing them with access to information and to act as a mentor in life skills by providing a comfortable, engaging, organized, and content rich classroom environment. The aim of classroom has always been to provide all learners with access to academic knowledge based in both content and process. I have consistently sought to alter my instruction to ensure that learners' learning opportunities are meaningful. I have always aimed to improve my ability to teach and assess learners' future ready-based (science, technology, engineering, arts and mathematics) learning in my high school biology classroom. Complicating matters, I did not have access to instructional tools and assessments that would reveal whether and to what extent learners were learning rich future ready practice. Thus, my teaching cycle of planning, instruction, assessment, and reflection revolved mostly around learners' mastery of biology content material. My classroom was dominated by teacher-led direct instruction and lectures to transmit a large body of scientific knowledge.

1.4 Context of Problem of Practice

I am one of four high school biology teachers at Greensburg Salem High School. I taught six of the ten general biology courses at my high school. The focus group for the study was the fall 2020 learners which included three of the six biology courses I taught during the 2020-2021 school year. At Greensburg Salem High School, we follow the block schedule which replaces the original eight to nine period day with four blocks. For the purposes of this study, blocks refer to the sections of the course or periods of the course if we followed a traditional period schedule. The blocks are heterogenous groups of learners that are pre-assigned to my learning roster prior to the start of the year by our administration. My learner roster included 68 learners (one 9^{th} grader, sixty-five – 10^{th} graders, two – 11^{th} graders) who were required to successfully enroll in and pass biology based on the school district graduation requirements and state-mandated curriculum. The biology classes I teach are either Regular Biology (RB) or Accelerated Biology (AB). For this study, the group included three RB biology classes during the scheduled semester. In my district, both biology courses (RB and AB) are inclusion courses, which means learners from the following subgroups -- General Education (GE), 504 Plan (504), Individualized Education Plan (IEP) or Gifted Individualized Education Plan (GIEP) learners -- can be learning alongside one another within the same class.

Tables 1, 2, 3, and 4 highlighted the block demographics as well as an overall summary of my entire roster demographics. For the purposes of summarizing the demographics as well as study data, I randomly assigned block letters (A, B, C) relating to my three class blocks and assigned (alphabetical and numerical codes, i.e. A2) to all learners. For the purposes of this study, blocks refer to the sections of the course or periods of the course if we followed a traditional period schedule. The blocks are heterogenous groups of learners that are pre-assigned to my learning roster prior to the start of the year by our administration. The demographics categories found within the tables were identified based on the data within the Greensburg Salem School District edInsight and eSchoolData programs. The edInsight and eSchoolData programs are systems that record family reported demographic information. Within the tables, I included the categories of academic grade, sex, primary language, racial background (African American, Caucasian/White, Multiracial, and Native Hawaiian or Pacific Islander), specially designed instruction (General Education (GE), 504 Plan (504), Individualized Education Plan (IEP) or Gifted Individualized Education Plan (GIEP) learners), specially designed instruction by sex and racial background, socioeconomic status (self-identified as living at or below the poverty level (PL)) and total learners to provide essential demographic information relating to the cultural context of my public high school classroom.

Table 1. Summary of Demographics for Block A – Fall 2020 – Regular Biology

Demographic Category	Block Specific Information	Quantitative Information	
Academic Grade	Grade 9	1	
	Grade 10	21	
	Grade 11	2	
	Grade 12	0	
Sex	Female	8	
	Male	16	
Primary Language	English	24	
Racial Background	African American (AA)	1	
	Caucasian/White (CW)	18	
	Multiracial (MR)	5	
	Native Hawaiian or Pacific Islander (NW/PI)	0	
Specially Designed Instruction	504	0	
	GE	15	
	GIEP	0	
	IEP	9	
Specially Designed Instruction by Sex and Racial Background	Female	AA	0
		CW	0
		MR	3
		NW/PI	0
	Male	AA	0
		CW	4
		MR	2
		NW/PI	0
Socioeconomic Status	PL	10	
Total Learners	Assigned Roster	24	

Block A was predominantly tenth grade learners (88%), male (66%), English language speaking (100%), and Caucasian/white (75%). There were 38% of learners in Block A identified to receive specially designed instruction relating to their IEP status with the remaining 62% of learners receiving general education instruction. Of the 38% of learners with an active IEP status, 33% were female and 67% were male. 56% of learners with IEP status were identified as multiracial. Block A had 24 total learners with 42% being self-identified as living at or below the poverty level. Block A was scheduled as a regular biology course within the Greensburg Salem School District.

Table 2. Summary of Demographics for Block B -- Fall 2020 -- Regular Biology

Demographic Category	Block Specific Information	Quantitative Information	
Academic Grade	Grade 9	0	
	Grade 10	17	
	Grade 11	0	
	Grade 12	0	
Sex	Female	10	
	Male	7	
Primary Language	English	17	
Racial Background	African American (AA)	2	
	Caucasian/White (CW)	10	
	Multiracial (MR)	5	
	Native Hawaiian or Pacific Islander (NW/PI)	0	
Specially Designed Instruction	504	0	
	GE	12	
	GIEP	0	
	IEP	5	
Specially Designed Instruction by Sex and Racial Background	Female	AA	0
		CW	2
		MR	1
		NW/PI	0
	Male	AA	0
		CW	1
		MR	1
		NW/PI	0
Socioeconomic Status	PL	9	
Total Learners	Assigned Roster	17	

Block B was predominantly tenth grade learners (100%), female (59%), English language speaking (100%), and Caucasian/white (59%). There were 29% of learners in Block A identified to receive specially designed instruction relating to their IEP status with the remaining 71% of learners receiving general education instruction. Of the 29% of learners with an active IEP status, 60% were female and 40% were male. 60% of learners with IEP status were identified as Caucasian/white. Block B had 17 total learners with 53% being self-identified as living at or below the poverty level. Block B was scheduled as a regular biology course within the Greensburg Salem School District.

Table 3. Summary of Demographics for Block C – Fall 2020 – Regular Biology

Demographic Category	Block Specific Information	Quantitative Information	
Academic Grade	Grade 9	0	
	Grade 10	27	
	Grade 11	0	
	Grade 12	0	
Sex	Female	14	
	Male	13	
Primary Language	English	27	
Racial Background	African American (AA)	3	
	Caucasian/White (CW)	23	
	Multiracial (MR)	0	
	Native Hawaiian or Pacific Islander (NW/PI)	1	
Specially Designed Instruction	504	0	
	GE	18	
	GIEP	1*	
	IEP	9*	
Specially Designed Instruction by Sex and Racial Background	Female	AA	0
		CW	3
		MR	0
		NW/PI	0
	Male	AA	1
		CW	4
		MR	0
		NW/PI	1
Socioeconomic Status	PL	12	
Total Learners	Assigned Roster	27	

Block C was predominantly tenth grade learners (100%), female (52%), English language speaking (100%), and Caucasian/white (85%). There were 30% of learners in Block C identified to receive specially designed instruction relating to their IEP status with the remaining 70% of learners receiving general education instruction (*one learner had an active GIEP in English and IEP in Mathematics in Science which caused the numbers to be off set regarding learners with specially designed instruction). Of the 30% of learners with an active IEP status, 33% were female and 67% were male. The 78% of learners with IEP status were identified as Caucasian/white. Block C had 27 total learners with 44% being self-identified as living at or below the poverty level. Block C was scheduled as a regular biology course within the Greensburg Salem School District.

Table 4. Summary of Demographics for All Blocks – Fall 2020 – Regular Biology

Demographic Category	Block Specific Information	Quantitative Information	
Academic Grade	Grade 9	1	
	Grade 10	65	
	Grade 11	2	
	Grade 12	0	
Sex	Female	32	
	Male	36	
Primary Language	English	68	
Racial Background	African American (AA)	6	
	Caucasian/White (CW)	51	
	Multiracial (MR)	10	
	Native Hawaiian or Pacific Islander (NW/PI)	1	
Specially Designed Instruction	504	0	
	GE	45	
	GIEP	1*	
	IEP	23*	
Specially Designed Instruction by Sex and Racial Background	Female	AA	0
		CW	5
		MR	4
		NW/PI	0
	Male	AA	1
		CW	9
		MR	3

		NW/PI	1
Socioeconomic Status	PL	31	
Total Learners	Assigned Roster	68	

My assigned roster was predominantly tenth grade learners (96%), male (53%), English language speaking (100%), and Caucasian/white (75%). There were 34% of learners on my roster identified to receive specially designed instruction relating to their IEP status with the remaining 66% of learners receiving general education instruction. Of the 34% of learners with an active IEP status, 39% were female and 61% were male. 61% of learners with IEP status were identified as Caucasian/white. My roster included 68 total learners with 46% being self-identified as living at or below the poverty level. All blocks were scheduled as a regular biology course within the Greensburg Salem School District.

Although there were heterogeneous subgroups within the individual classes, all learners were expected to cover the same curriculum, in the same amount of time, unless permitted by the state of Pennsylvania to receive a modified curriculum. Learners were engaged in the curriculum from September 2020 to January 2021 with the study occurring in December 2020. In addition to the successful completion and passing of course assignments and assessments, learners were required to take the Pennsylvania Biology Keystone Exam at the end of the course and achieve an Advanced or Proficient ranking.

1.5 Broader Problem Area & Organizational System

Across the entire state for the 2018-2019 school year, 63% of learners earned either advanced or proficient markings while 37% fell in the below or below basic category. In my individual district for the 2018-2019 school year, 74% of learners earned advanced or proficient while 26% fell into the below or below basic level. These percentages represent the achievement of all learners but do not highlight their individual growth scores. Across the entire state for the 2019-2020 school year, 66% of learners earned either advanced or proficient markings while 34% fell in the below or below basic category. In my individual district for the 2019-2020 school year, 73.9% of learners earned advanced or proficient while 26.1% fell into the below or below basic level. These percentages represent the achievement of all learners but do not highlight their individual growth scores. The data comparison between the 2018-2019 and 2019-2020 school year indicated a slightly downward trend for all learners, however, the state data did indicate a positive trend regarding learners with disabilities. The statewide goal by 2030 is to have 83% of all learners to achieve either advanced or proficient markings (Future Ready, 2021).

My school was the only high school in the Greensburg Salem School District – a suburban school district located approximately an hour east of the city of Pittsburgh. The complex system of our district involved many interdependent parts connecting to educate our youth. The district boundaries of Greensburg Salem include urban, suburban and rural households. The total population of Greensburg Salem was 26,744 (according to the 2011 PA County Data Book). The district had a 21:1 learner-teacher ratio, 50 athletic teams, 93% graduation rate, 94% attendance rate, and 2,729 K-12 learners. Our instructional system included our district policies, building routines, relationships, physical resources, human resources, and identity of our community (Abercrombie, 2015). The Greensburg Salem High School had an enrollment of 782, 9th through 12th grade learners with 38.4% being self-identified as living at or below the poverty level, 0.3% being English Language Learners, 15.5% being identified for special education services, 0.6% being involved in the foster care system, 1.9% being identified as homeless, and 0% being connected to the military. The percent enrollment by gender for males and females was 50.5% and 49.5%, respectively. The percent enrollment by race/ethnicity was 0% American Indian/Alaskan, 0.9% Asian, 5.5% Black, 0.1% Native Hawaiian, 1.2% Hispanic, 84.9% white, and 7.4% 2 or More Races (Future Ready, 2021). The Greensburg Salem School District had an enrollment of 2666, K through 12th grade learners with 42.5% being self-identified as living at or below the poverty level, 0.5% being English Language Learners, 18.8% being identified for special education services, 0.8% being involved in the foster care system, 1.6% being identified as homeless, and 0% being connected to the military. The percent enrollment by gender for males and females was 50.2% and 49.8%, respectively. The percent enrollment by race/ethnicity was 0% American Indian/Alaskan, 0.4% Asian, 5.9% Black, 0.1% Native Hawaiian, 2.4% Hispanic, 82.9% white, and 8.2% 2 or More Races (Future Ready, 2021).

In February of 2019, the Greensburg Salem School District was mandated by the state of Pennsylvania to form an Additional Targeted Support and Improvement Committee (ATSI) due to data analysis from the Future Ready Index (FRI). Our Future Ready Index for our district indicated that our area of extreme need is the subgroup of special education learners. The three indicators of the need were achievement in mathematics and English language arts (ELA), growth in three academic areas (mathematics, English language and Biology), and graduation rate for the specific subgroup of exceptional learners (labeled by the state Future Ready Index as learners with disabilities). The achievement in math and ELA cut score for the state of Pennsylvania was 31.5% and our special education population had a recorded achievement level of 19.8%. The growth indicator was indicated by the Pennsylvania Value Added Assessment System (PVAAS). The Pennsylvania growth cut score was 1.0 with our district growth value being assigned a -2.53. The cut score was the minimal acceptable growth score calculated by PVAAS. The growth score was calculated using yearly state assessment data for each individual learner. The final indicator for the Future Ready Index was graduation rate with the state cut score being 79.35% and our district score was 75.71% for the cohort of learners analyzed. Based on the failure to meet the state cut score for our special education learners, we worked to analyze district practices overall and at the high school level with the assistance of the Westmoreland Intermediate Unit #7 and the Pennsylvania Essential Practices for School guidelines. After data analysis and district discussions, our high school community was placed in a phase of continuous school improvement based on the goals and objectives, as outlined by our ATSI committee. The ATSI committee indicated two primary goals for our high school: implement Multi-Tiered System of Supports (MTSS) and monitor learner learning to improve instructional practice as well as inform personalized learning. The committee outlined the following four objectives for our continuous improvement cycle:

1. Establish a training and implementation plan for MTSS framework
2. Provide professional development for future ready instructional strategies
3. Develop coherent assessment plan that establishes accountability for the use of assessments and assessment data
4. Develop professional development addressing implementation of effective assessments that lead to consistent monitoring of learner learning to improve instruction

The ATSI committee focus and educational future ready movement connected with my problem of practice focus because my aim was to improve instructional practices and assessment strategies to increase learner learning in competency areas to prepare learners for a successful postsecondary life transition. The ATSI committee work and my classroom structure aligned with the following targeted strategies of – ensuring safe and supportive environments, developing language skills, implementing tiered intervention approaches, and attending to transition points – which were noted as being high-leverage arenas to reduce within-system inequalities (O'Day, 2016).

Our district work and the ATSI committee focus was operating under ESSA and the Pennsylvania Department of Education direction. ESSA had numerous positive impact points in classrooms for educators. The academic standards under ESSA had to include challenging academic content in reading, math, and science. Also, ESSA promoted a focus on preparing learners to succeed in a college/training program and in a career path. The ESSA framework for all states called attention to all learners. ESSA supported Universal Design for Learning (UDL) and personalized learning. ESSA was a positive impact on my problem of practice because the act increased the focus of schools to prepare learners for post-secondary life via multiple pathways (college, training program, career, etc.). Thus, ESSA called for learners to have content knowledge and future ready skills/competencies. Overall, ESSA called for classrooms to focus on the individual learning experiences of all learners. Although there were many positive influences, I believe ESSA's focus on standardized testing in reading, math, and science had negative impact on learners. ESSA negatively influenced my problem of practice because of the mandate of annual testing. Therefore, standardized testing standardized our curriculum allowing for limited time to differentiate instruction for all learners and teaching 21st century and future ready competency skills at an in-depth level.

Our high school had previous success with most aspects of the ESSA framework such as meeting the goal for the future ready index for most subgroups. We had also successfully integrated all standards into our curriculum and school culture. The areas we needed to focus on included the future ready index for exceptional learners, Act 158 implementations for all learners, and the additional targeted support and improvement designation we received in 2019 due to our future ready index data indicators. The ATSI committee was tasked with developing goals and objectives around ESSA and the state designation. Table 5 outlines the ATSI committee focus areas and connects to the 2012 Beaver and Weinbaum framework (human capital, social capital, program coherence and resources) for areas of need for school system capacity.

Table 5. Greensburg Salem ATSI Goals/Objectives with School System Capacity

ATSI Program Goals and Objectives	Area of Need for School System Capacity
High School ATSI Goals:	
1.Implement Multi-Tiered System of Supports (MTSS)	Human Capital Social Capital Program Coherence
2.Identify assessment and monitor learner learning to improve instructional practice and inform personalized learning	
High School ATSI Objectives:	
1.Establish a training and implementation plans for MTSS framework	Resources – Materials and Professional Development
2.Provide professional development for future ready instructional strategies	
3.Develop coherent assessment plan that establishes accountability for the use of assessments and assessment data	Resources – Support Staff, Materials, Assessment Instruments, Classroom Technology and Professional Development
4.Develop professional development addressing implementation of effective assessments that lead to consistent monitoring of learner learning to improve instruction	

Human capital was broadly defined as the knowledge, skills, and abilities of members of the school system, while social capital referred to the relationships among individuals within the system. Program coherence related to the extent to which the system framework was coordinated with clear learning goals, effective curriculum resources and promising instructional frameworks that were sustainable over time. Lastly, resources were identified as the physical resources (i.e.

Technology, instructional materials, books, etc.) or professional resources (i.e. Instructional support, professional training, class size, etc.) available (Beaver, 2012).

In terms of the 2012 Beaver and Weinbaum's classification of schools, I believe our high school was a medium capacity school transitioning to a high capacity school. We had committed and dedicated staff that implement academic instructional strategies to help all learners. However, as a complex system, we did not have all of the human capital, social capital, program coherence or resources for integrating MTSS or effective forms of assessment to drive instructional practices. The system and the current outcomes being experienced were the result of the tools and materials, processes, and interactions among the people within our school (Bryk, 2016).

1.6 Review of Supporting Knowledge

The purpose of the literature review was to understand how rigorous biology instruction had been understood in the research literature and to examine strategies in biology that promote an increase learner learning and assessment in the 21st century and future ready competency areas. The questions I brought to my review of the literature were:

1. How do others understand and define future ready learning relating to STEM coursework?
2. What are recommended practices for instruction of future ready learning in biology?
3. What are noteworthy approaches for assessing future ready instruction and learning in biology?

1.6.1 Roadmap

I highlighted and outlined themes generated from my review of the literature. My review was organized into the following sections: conceptualizations of future ready and 21st century learning relating to STEM coursework, approaches for teaching future ready competency skills, and approaches for assessing future ready competency skills. Together, the exploration of these themes enabled me to generate promising ideas for promoting change in my professional context.

1.6.1.1 How do others understand and define future ready learning relating to STEM coursework?

For years, stakeholders have voiced concern about the mediocre academic performance of learners in the United States of America in comparison to our international competitors (Hansen, 2014; Bair, 2014). Many principles present in future ready learning started with the present-day STEM movement which began in the 1990s with the use of the acronym SMET, representing science, mathematics, engineering, and technology, by the National Science Foundation (NSF) (Sanders 2009, Bybee 2013). SMET has since been replaced with the STEM (science, technology, engineering, and mathematics) acronym which has gained additional disciplines throughout the years. There are different conceptualizations of STEM in education now that have become STEAM, STEMM, and STREAM where instruction includes the original science, technology, engineering and mathematics components with an additional focus on arts and humanities, agriculture, architecture, manufacturing, as well as reading (Herro, 2016; Quigley, 2019). The lack of a consistent SMET definition and variation of integrated versus discrete discipline practices created the large range of SMET acronyms. Millions of dollars have been invested on a federal and state-level to improve future ready educational programs as well as learner achievement. In addition to the millions of dollars spent on future ready education programs, a significant amount of time has been invested in STEM education as well as future ready learning reform since the original SMET acronym of the 1990s.

Broadly, future ready education connects with the principles of STEAM (science, technology, engineering, arts, and mathematics) learning, with those five areas overlapping into one curriculum or stand alone in individual subject classrooms with the infusion of the other subjects at varying points throughout the course material. More specifically, future ready learning aligns with classroom characteristics of interdisciplinary, authentic, learner-centered, project-technology based approach to learning that involves science, technology, engineering, arts and humanities, and mathematics content while promoting collaboration and problem-solving skills (Guzy, 2017; Israel, 2013; Hansen, 2014; Herro, 2016; Quigley, 2016/2017).

For others, future ready learning incorporates the infusion of art, design principles, and engineering habits of mind into the individual silos of STEM: science, technology, engineering, arts, and mathematics (Basham, 2013; Sochacka, 2016). The engineering habits of mind are defined as systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations (Basham, 2013). For others still, the infusion of the arts in future ready learning opportunities connects with the Capacities for Imaginative Learning: noticing deeply, embodying, questioning, making connections, identifying specific patterns, exhibiting empathy in social situations, living in ambiguity, creating meaning from materials, acting on observations, and reflecting (Dow, 2014). The variations of STEM movements in education, including the current future ready focus, all aim at promoting the acquisition of content knowledge while developing a full suite of higher ordering abilities, such as critical analysis, creative thinking, social skills, ethical understanding, and a global perspective for all learners.

Advocates of future ready learning experiences generally support them based on expectations that future ready can support learners' development of content knowledge and 21st century skills such as collaboration, problem-solving, critical thinking, and communication. The broad goal of most educational instructions is to prepare future citizens to solve the nation's and world's pressing issues through utilizing problem-solving skills, innovative strategies, creative mindsets, effective communication strategies, and new content knowledge (Quigley, 2016/2017). The nature of future ready and STEM learning is designed to promote divergent and convergent thinking as well as the use of systems thinking tools (Sochacka, 2016). The global skills and content focus of future ready learning correlates with the professional skills employers are looking for - ability to work in a team, make decisions and problem solve, plan/organize/prioritize work, communicate via verbal and written means, gather/process information, analyze quantitative/qualitative data, proficiency with computer software programs, and self-regulation, as reported by Forbes Magazine (Adams, 2013).

Future ready learning can be viewed through a science lens to involve understanding, using and interpreting scientific explanations of the natural world; generating and evaluate scientific evidence and explanations; understanding the development of scientific knowledge; and participating productively in scientific practices and educational discourse. Those fundamental pillars for a scientific literate learner are evident in classrooms where instruction and activities are content-rich inquiries and non-routine problem-solving (Windschitl, 2009). Recent studies indicate that learners are routinely engaging in classroom activities without a full understanding of how key concepts connect, therefore, they are unable to explain scientific phenomena at an in-depth level and use scientific evidence to support arguments (Windschitl, 2009). The National Academies of Science highlight the following reform based instructional approaches that cultivate content learning and skill competencies that teachers should focus on:

1. Identification of curriculum main scientific ideas and uses those ideas as the basis of instruction
2. Elicit learner conceptions of phenomena and adapt further instruction based on learner understanding
3. Co-construct hypotheses and problems related to scientific phenomena
4. Provide learners with resources and experience relevant to answering content essential questions (ie. readings, technology tools, hands-on work)
5. Support learners in monitoring their progress toward defined goals
6. Monitor learner understanding of science ideas and engagement in authentic scientific discourse and practices
7. Promote the comparison and integration of ideas across different representations
8. Prompt the use of data as evidence to support explanatory models and arguments
9. Ask learners to critique the intellectual work of others in consistent scientific ways

The reform based instructional approaches connects with the education policy efforts and updated curriculum frameworks, such as the Next Generation Science Standards (Livstrom, 2019). Federally, biology is addressed in many standards from the Next Generation Science Standards to Pennsylvania Academic Standards with many of those standards and standardized assessments emphasizing biology specific content. future ready skills or process skills are not specifically noted unless one gathers them from the unifying themes, crosscutting concepts, and science/engineering practices of the numerous standards/curriculum documents.

Although there is variation in understanding and implementation of future ready and STEM learning, both areas intend to prepare learners for success in a post-secondary life and workforce. Promoters of future ready learning as well as STEM learning promote the acquisition of knowledge along with process skills. Many note the importance of higher order process skills, such as critical thinking, information analysis, communication, and collaboration.

1.6.1.2 What are recommended practices for instruction of future ready learning in biology?

The recent aim to increase learner achievement and success in future ready related courses and jobs has led to an increase in proposed instructional frameworks for future ready and varied instructional methods. Although there is not a clear definition of leading instructional best practices, there is a good deal of agreement in the field about the types of instruction that will support learners' future ready learning. There is also acknowledgement that shifts in teacher practice will take time regardless of subject area or academic level.

In order to develop learners capable of functioning and thriving in a highly technological world that draws on multiple disciplines, teaching practices need to shift from teacher-focused to learner-focused (Yaduvanshi, 2018) using the following instructional framework, especially in STEM related courses such as biology. An instructional framework provided by Quigley, Herro, and Jamil (2017) offers insights about what this work may involve. The framework includes two broad domains: instructional content and learning context. The instructional content domain focuses on three dimensions of problem-based delivery, discipline integration, and problem-solving skills. Problem-based delivery frames learning with real-world problems with multiple disciplinary connections that align purposefully selected content with standards. The discipline integration dimension clearly and seamlessly synthesizes connections across discipline areas. The problem-solving skills dimension looks to capture ways skills (cognitive, interactional, and creative) can be developed through learning experiences. The learning context domain focuses on three dimensions of instructional approaches, assessment practices, and equitable participation. The instructional approaches layer of the framework aims for teachers to create learning ecosystems that are inquiry rich with multiple domain levels and efficient technology integration. The assessment practices dimension captures an iterative assessment process that focuses on authentic alignment with real-world connections and regular as well as consistent feedback with multiple sources of data. The equitable participation dimension captures ways classroom facilitation promotes access and engagement for all learnings while ensuring relevant tasks, responsiveness and learner choice.

In order to meet the future ready needs of our learners, our classrooms need to be flexible in pacing, responsive to learner learning with appropriate planning, and collaborative, problem-solving, and technology-rich learning ecosystems (Herro, 2016; Livstrom, 2019). The following instructional strategies - cooperative learning, project-based learning, inquiry learning, and socio-scientific learning - allow for learners to explore content material while building necessary life skills. All the strategies aim to provide learners with practical and authentic learning experiences while increasing understanding of the nature of science, subject matter, and complex empirical work as well as developing teamwork skills, an interest in science, practical skills, and scientific reasoning (Assefa, 2011; Bennett, 2018). Cooperative learning is grounded in social constructivist theory where learners learn and achieve more while working in a group with their peers. Cooperative learning has been shown to enhance scientific process skills and increase content knowledge achievement (Yaduvanski, 2019; POGIL, 2019). Project-based learning is a learning process that is learner designed and led. Learners examine practical ill-defined problems and investigations. The processes of project-based learning are driven by current knowledge in communities of inquiry where learners draw on the expertise of resources and others to draw conclusions through stages of project design (Bennett, 2018; Hadinugrahaningsih, 2017; Suwono, 2018). Inquiry learning is suggested to be the learning of how scientific endeavors takes place, where the learners are doing science and performing scientific practices (Tsybulsky, 2018). There is a pedagogical approach called POGIL (Process Oriented Guided Inquiry Learning) that combines content material, process skills, and inquiry learning. POGIL has been successfully used in secondary and post-secondary biology courses to increase both content knowledge and process skills such as teamwork, effective communication, information processing, problem-solving, and critical thinking. POGIL is built on the frameworks of constructivism, inquiry and cooperative learning.

Another pedagogical approach is SENCER (Science Education For New Civic Engagements and Responsibilities). SENCER is a specific pedagogical approach that connects theoretical biology concepts such as cells, pollution, ecosystems, and energy, with complex social issues. Learners participating in SENCER are engaging in scientific reasoning, inquiry, and data collection to gain knowledge and synthesize answers to complex questions. Socioscientific learning (SSL) involves science content and social important (controversial issues). Socioscientific issues (SSI) are incorporated into socioscientific learning exercises due to their conceptual, procedural or technological content connection. SSL instructional models include the following features: creating opportunities for exploring all dimensions of the SSI, building instruction around culturally relevant SSI engaging learners in scientific processes/practices (Topcu, 2018).

Although there is variation in understanding and implementation of future ready learning in biology, there has been shifts in instructional frameworks and activities that promote the development of future ready skills while creating an engaging learning ecosystem. The instructional framework provided by Quigley, Herro, and Jamil (2017) offers a balanced framework that focuses on purposeful multiple discipline instruction through authentic and problem-based experiences. The framework also promotes responsive instruction and varied assessment for all learners. The framework structure is reinforced by two pedagogical approaches POGIL and SENCER. The framework and the approaches call for collaborative, inquiry learning opportunities that are authentic, relevant and engaging for all learners. There is correlation between the framework, approaches and the skills noted to be critical for future ready learning. There is a focus on the acquisition of knowledge along with process skills, such as, higher order process skills, such as critical thinking, information analysis, communication, and collaboration.

1.6.1.3 What are noteworthy approaches for assessing future ready instruction and learning in biology?

There is a heightened instructional focus on ensuring all learners are exposed to content knowledge, 21st century skills, and future ready competencies in science classrooms throughout the United States. Despite the national and global trend in future ready education, there is a lack of comprehensive research on assessment tools for measuring 21st century skills and future ready competencies (Herro, 2017). It is critical that our instructional focus and assessments are aligned to best represent the kinds of knowledge and competencies we want to focus on in our classrooms. Learners must gain the necessary skills to prepare them for a global workforce in a fast-paced and information-driven economy (Gane, 2018). When instruction and assessments do not align, we gain an inaccurate picture of teacher instruction and learner knowledge.

Assessments are critical in providing learners and teachers the necessary formative feedback on knowledge and competencies gained to adjust instruction. In addition to formative feedback, summative assessments can provide learners and teachers with a view of critical benchmarks met regarding both what learners are expected to know (content) and expected to do (skills and competencies). While assessments provide teachers with a lens into learner knowledge, reflection on assessments can provide teachers with insight into the official, enacted, and experienced curriculum within that classroom environment. There are many limitations for teacher instruction and assessments which include planning time, instructional time, teacher knowledge, and access to assessment tools (Brown, 2012). Those limitations influence the nature of assessments in terms of development, implementation, and reflection.

When considering development of assessments, teachers need to consider the ways in which those tools are affording learners the opportunity to demonstrate their content knowledge as well as their cognition of scientific reasoning and capacity for knowledge-in-use. Traditional assessments of knowledge and skill for learners are structured to promote basic recall and standardized structure of content material (Gane, 2018). Scientific reasoning evaluation involves higher order thinking where learners are asked to analyze information, evaluate conditions, as well as rationally thinking using creative experience (Yanto, 2019). To assess future ready learning and competencies, assessments need to ask the learner to show what they know, their process of learning as well as their way of thinking. Process skills can be defined as oral and written communication, teamwork, information processing, critical thinking, problem solving, management, and assessment (self, peer and metacognition) (Simonson, 2019). The process skills defined by the POGIL (Process Oriented Guided Inquiry Learning) project as significant are also found in numerous definitions and understandings of future ready learning components. Process skills along with content knowledge can be assessed using activities focused on the question types of directed, convergent and divergent along with the learning cycle of a learner through the stages of exploration, concept invention, and application (Simonson, 2019). The learning cycle noted by

POGIL project is similar to the natural problem solving flow of the 5E instructional model (engage, explore, explain, elaborate and evaluate. The Enhancing Learning by Improving Process Skills in STEM (ELIPSS) Project has focused on the development of process skills rubrics for both learner interactions and learner products. The ELIPSS Project by the National Science Foundation is currently partnered with the POGIL Project. ELIPSS and POGIL are working to develop resources that assess and provide feedback on process skills. The ELIPSS Program recognizes that process skills are broadly known as professional, workplace, lifelong learning, transferable, and soft skills (ELIPSS, 2019). In addition to rubrics, effective assessment tools for evaluating learner skills and competencies include: online extended constructed responses, gaming/simulation activities, and computer adapted testing (Yanto, 2019). The Survey of Enacted Curriculum (SEC), Collaborative Problem Solving Framework (CPS), Educational Testing Services CPS (ETS CPS), and Co-Measure are tools that can be used in the reflection of classroom instruction and assessment (Herro, 2017; Brown, 2012).

The overall structure of the public education system and the policies that impact our classrooms every day influence pacing, standards, and call for accountability through standardized measures. However, learning opportunities and assessments can be aligned to connect both future ready skill development and growth in content knowledge. Non-traditional forms of formative and summative assessments can be used to provide learners with reflective feedback to grow in their knowledge and competencies.

1.6.2 Synthesis

In many ways, this literature review validated my vision of future ready learning in that future ready instruction needed to include a partnership of all content areas - science, technology, engineering, art, and mathematics, within a classroom that was learner-centered, problem-solving focused, and rigorous. Many supporters of future ready learning experiences and process skills noted learner development of content knowledge and future ready/21st century skills such as collaboration, problem-solving, critical thinking, and communication through learner-centered experiences are critical in science education (Basham, 2013; Guzy, 2017; Israel, 2013; Hansen, 2014; Herro, 2016; Quigley, 2016/2017). After reflecting on my current practices, I believe that I had implemented portions of future ready instruction such as cooperative learning groups, creative problem-solving strategies, and variation in scientific knowledge presentation, however, I did not have a formal instructional framework or process skill focused assessments other than my biology curriculum standards, traditional classroom content assessments, and the Biology Keystone Assessment. Many studies noted the same struggles with implementing future ready focused instruction that I had including limited expertise in all silos of future ready, curriculum pacing, limited professional collaboration time, and limited technology resources. I was surprised by the broad and varied perspectives on how future ready education was defined and the range of instructional approaches in individual classrooms and school systems.

Not surprisingly, I did not find a variety of future ready skill focused assessment practices. At a federal, state, and local level, our current future ready assessment tools more easily, quickly, and effectively measure content specific knowledge. The call for accountability of learners, teachers, and school districts occurred largely through standardized measures. In order to meet the needs of our learners, the implementation of effective assessment strategies to evaluate both content knowledge and future ready skills was and still is necessary. Although the structure of accountability at a state and federal level appears to not be changing, I impacted learning by shifting my classroom framework to include collaborative, inquiry approaches as well as mixed method assessment structures that partnered traditional and non-traditional forms of assessment/feedback.

In other ways, this literature review shifted my vision of learning in that I no longer view STEM classrooms as only the individual content silos where future ready skills were developed but as cross-curricular learning ecosystems where all content areas are incorporated into lessons with process skills by the professional educator in the room. I used to be skeptical of implementing future ready content in my classroom due to science specific expertise, specifically biology and chemistry. I now believe curriculum can be covered at the same rigorous level through changing instructional strategies toward learner-centered, authentic methods and varying assessments to evaluate both learner content knowledge as well as skills.

1.7 Conclusion

Under The Every Learner Succeeds Act (ESSA) of 2015, the state of Pennsylvania launched a framework for holding schools accountable. Within that framework, the Future Ready Index served as a measure of the school learning climate. The Future Ready Index (FRI) identified achievement goals for content growth and mastery, graduation rates, post-secondary transitions to career/school/military, and AP exam achievement for different subgroups of learners. In addition to the FRI, Pennsylvania enacted Act 158 which provided alternative pathways to graduation. Although the state recognized the importance of both postsecondary skills and content knowledge, the biology curriculum at a state and local level was largely focused on content knowledge mastery. The standards and eligible content did not explicitly recognize that our classrooms were situated within schools that have their own identities, climates, and needs. Our schools were embedded and operating within district systems that were focused on initiatives and accountability demands while aiming to help our learners grow (Biag, 2017). Through the attainment of more knowledge about the practices and assessment strategies for future ready learning in biology that equated to the effective pairing of content exploration and skill development, the instruction and assessments within my classroom improved learner content mastery along with future ready competency skills in Biology for all learners. Although learning strategies and assessments were altered, my curriculum scope and sequence achieved the requirements of local, state and federal standards.

The traditional structure of our school limits instructional time as well as pacing due to the strict accountability framework relating to standards and eligible content, however, there were shifts in education and in our local district administration that promoted equitable learning for all learners and teacher empowerment to continue to learn for the sake of improving instruction.

There had been a shift with faculty focus and support toward increasing future ready skills while still maintaining academic rigor in our courses. Due to the shifts in education and administrative support, there was flexibility in classroom instruction that enabled instruction for the union of skill and content instruction. In addition to the shifts in administrative support, I was able to obtain professional development on new instructional frameworks and assessment strategies that related to both content and future ready skills. The professional development and administrative support increased teacher motivation toward shifting instructional practices despite the fear of lack of curriculum flexibility, time and the influence of required standards as well as eligible content in my biology classroom. The union of skill and content instruction allowed for pacing and time requirements to be managed while meeting the future ready needs of learners. Figure 3 highlights the forces for change and the forces that resisted change in my place of practice.

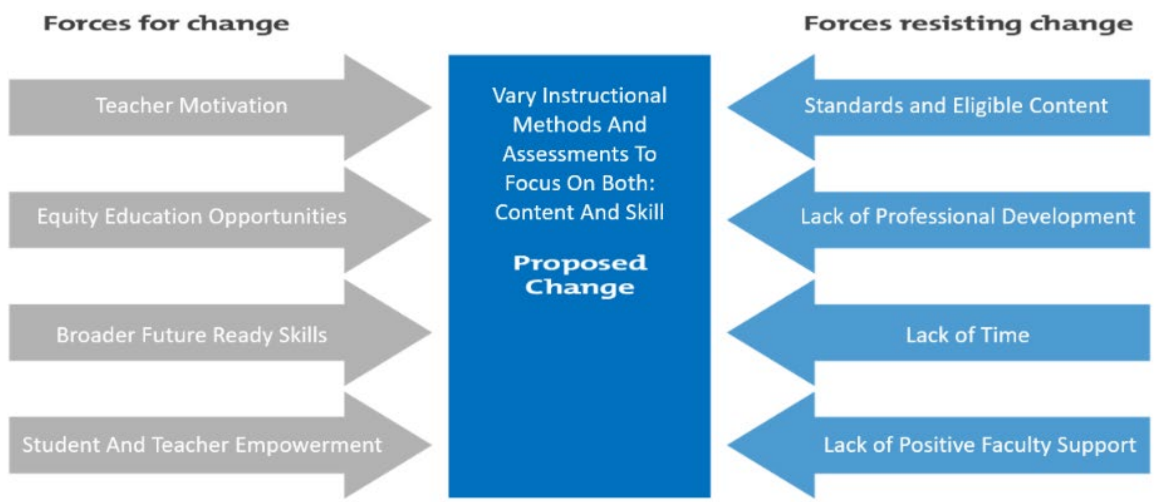

Figure 3. Force Field Analysis Map[3]

In the spirit of system changes, I will end with a quote from William Blake, "I must create a system, or be enslav'd by another man's." The instructional system I created aimed to function within the broad, less flexible public-school system while responding to the personalized needs of my learning ecosystem. The learning ecosystem needed to be structured to develop both content knowledge and process skills through equitable and engaging learning opportunities through productive learner-learner and learner-teacher interactions. Purposeful instruction that focused on skill development through deliberately designed content activity opportunities allowed for individual learners to continue to grow and develop.

[3] The forces for change and forces that resisted change in this diagram created a constant shift in my problem of practice.

2.0 Theory of Improvement & Implementation Plan

Through engaging instructional strategies and effective assessment techniques, I aimed to increase both content knowledge and use of future ready skills, specifically interpersonal communication, of learners in a required high school Biology course. The initial aim was to increase both knowledge and use of interpersonal communication skills from individual learner baseline levels by 10% over the course of three units (approximately one month). During the impact of COVID-19 on many areas of instruction, my study was limited to one unit of study instead of three. The overall aim was to improve both teacher instruction and learner skill development, which were drivers identified in Figure 4. The ESSA Framework and Future Ready Index called for learners to grow in both content knowledge and process skills, however, the traditional structure of my classroom did not explicitly prompt the acquisition of both. Through the purposefully planning, development of classroom norms and the implementation of effective learning experiences (driver two: teacher instruction), a classroom learning ecosystem was developed to ensure learners develop process skills (driver one: learner skill development) while growing in their content knowledge.

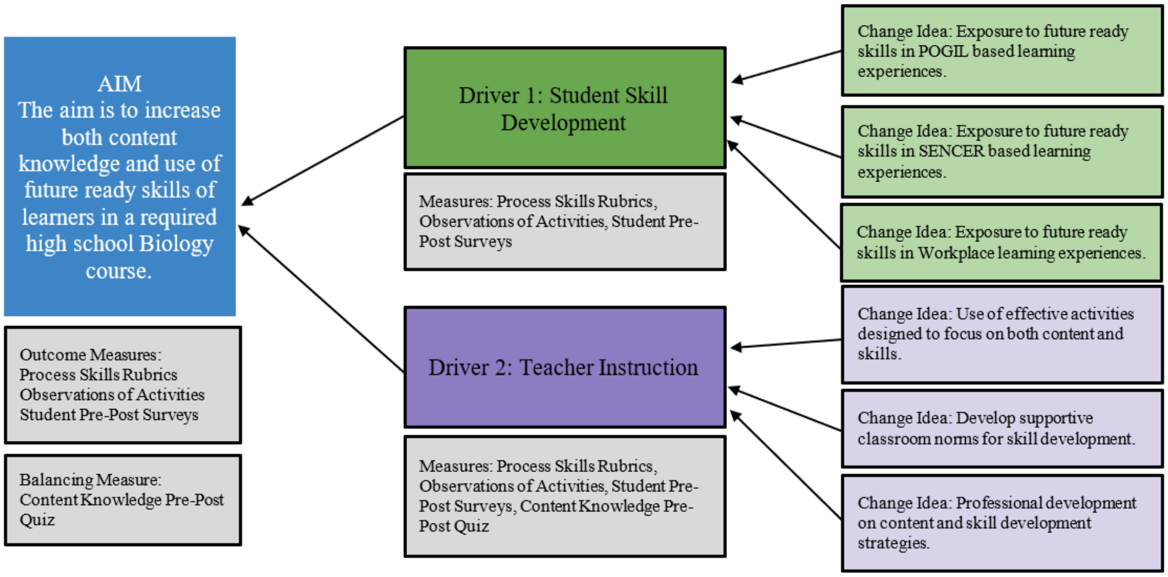

Figure 4. Driver Diagram of Practice[4]

2.1 Theory of Improvement

There were many policy influences from a federal, statement and local level. All levels of policy influences interacted with one another to impact classroom instruction and learning outcomes for all learners. At the federal level the most recent act to influence policy was the Every Learner Succeeds Act (ESSA). The ESSA Act was enacted in 2015 and was a reauthorization of the Elementary and Secondary Education Act. In 2020, ESSA was the primary law for K-12 education. Under ESSA, states had more flexibility in the education plans for their schools with a framework. The framework needed to include: academic standards, annual testing, school

[4] To achieve the aim, driver one and driver two were addressed in my biology classroom.

accountability, goals for academic achievement, plans for supporting/improving struggling schools, and state as well as local report cards. At a local level, there were multiple stakeholders involved in policy influences – district administration, teachers, learners, and community representatives (families, business, organizations). Figure 5 highlights the connections between policy influence from a federal, state, and local level.

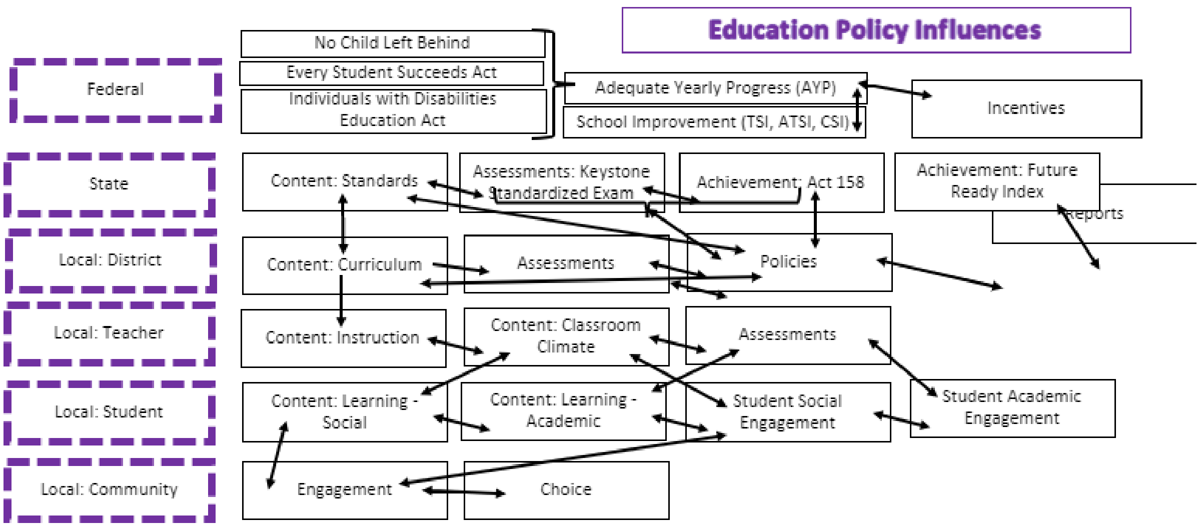

Figure 5. Education Policy Influences[5]

Under ESSA, the state of Pennsylvania launched a framework for holding schools accountable. Within that framework, there was a measure of the school learning climate called the Future Ready Index. The Future Ready Index (FRI) identified achievement goals for content growth and mastery, graduation rates, post-secondary transitions to career/school/military, and AP exam achievement, for different subgroups of learners. In addition to the FRI, Pennsylvania enacted Act 158 which provided alternative pathways to graduation. Although the state recognized

[5] The primary federal educational policy that influenced state and local policies was ESSA.

the importance of both postsecondary skills and content knowledge, the biology curriculum at a state and local level was largely focused on content knowledge mastery.

Under ESSA, the academic standards at a state level included challenging academic content in reading, math, and science. ESSA promoted a focus on preparing learners to succeed in a college/training program and in a career path. The ESSA framework called attention to all learners. ESSA supported Universal Design for Learning (UDL) and personalized learning. Just as No Child Left Behind (NCLB), ESSA called for standardized state testing in reading, math, and science. The frequency of testing depended on the subject and grade level of the learner.

ESSA positively impacted my professional practice because of the increasing focus in schools to prepare learners for post-secondary life via multiple pathways (college, training program, career, etc.). ESSA identified that all learners need both content knowledge and future ready skills/competencies. ESSA also shifted classroom focus and instruction to the individual learning experiences and needs of all learners. ESSA negatively influenced my professional practice because of the mandate of annual standardized testing that had standardized our curriculum allowing for limited time to differentiate instruction for all learners and teaching 21st century and STEAM competency skills at an in-depth level.

My theory of improvement was that when effective activities (designed to focus on both content and skill development) are implemented and learners were exposed to future ready skills in activities, such as POGIL (Process Oriented Guided Inquiry Learning), then learners' content knowledge and use of future ready skills in high school Biology would increase. The increase in both content knowledge and future ready competency skills improved learners' future readiness and aligned with policy indicators such as: Act 158, Future Ready Index and the Keystone Biology Exam.

2.2 Inquiry Intervention

As stated by my theory of improvement, when effective activities (designed to focus on both content and skill development) were implemented and learners were exposed to future ready skills in activities, such as POGIL (Process Oriented Guided Inquiry Learning), then learners' content knowledge and use of future ready competency skills in high school Biology increased. The POGIL Project and instructional framework is a pedagogy based in human learning research, content material, and process skills. The POGIL Project started in the early 1990s with the academic discipline of chemistry and has since evolved to include many academic disciplines and levels of education. POGIL was not the simple integration of a future ready project where the pillars of science, technology, engineering, arts and mathematics were incorporated or my traditional teacher-led, teacher-paced instruction.

POGIL was an active learning opportunity that promoted the use of future ready instructional principles, knowledge development, and collaborative group work. The POGIL framework shifted the role of the teacher to a facilitator and the role of learners from passive learners to active participates. All learners were provided roles with specific characteristics and a process skill focus for each POGIL activity. The teacher offered content knowledge checks for learners while providing scaffolded support to provide positive reinforcement and coaching of roles as well as the focus process skill. The POGIL approach and instructional intervention incorporated discipline integration, classroom environment engagement norms, and future ready skills. A critical piece of POGIL implementation was the overall design of the POGIL activity that was developed with specific content learning cycle activity levels and question types based on visual models. The learning cycle activity levels within the POGIL activity involved stages of complexity (explore, invent, and apply), process levels (orient, induce or deduce), and goals (data acquisition, patterns, and higher-level thinking). The question types within the POGIL activity involved the following question types: directed (questions that require one right answer), convergent (questions that require the bringing together of multiple contexts to develop a solution), and divergent (questions with no specific answer, but rather exercises one's ability to think broadly about a certain topic). Being that POGIL aligned both content and skill development, the implementation of the POGIL framework allowed for the requirements relating to standards, future readiness, and pacing to be met within my Biology courses.

The learning principles within POGIL connected peers, interest and academic orientation with design principles of open communication and active learning opportunities. The POGIL framework connected peers through explicit role assignment and a POGIL team structure that included the following: the manager, recorder, presenter, and reflector. The manager was responsible for time management, task assignments, and ensures equal contributions amongst group members. The recorder archived decisions and conclusions while keeping track of learning and thought processes. The presenter communicated questions and results on behalf of the POGIL team. The reflector observed team dynamics and problem solving processes, reports on teams' process and effectiveness.

The activities within POGIL were centered around learning content while developing interpersonal communication. The structure of POGIL also allows for the following future ready process skills – information processing, critical thinking, problem-solving, written and oral communication, interpersonal communication, teamwork, management as well as assessment and metacognition – to be practiced. The future ready process skills emphasized within the structure of the active learning opportunities POGIL provided relating to future ready process skill is defined further in Table 6. Each POGIL activity is approached through a content attentive and specific skill focused lens. Although the POGIL activities had a specific skill focus, all skills noted in Table 6 were used throughout the POGIL progress due to the process oriented (information processing and management), guided inquiry learning (critical thinking and problem-solving), collaborative instructional approach (interpersonal communication, team work, as well as assessment and metacognition).

Table 6. POGIL Future Ready Process Skills

Process Skill	Definition
Interpersonal Communication (Oral and Written)	Oral communication: Exchanging information and understanding through speaking, listening, and non-verbal behaviors. Written communication: Conveying information and understanding to an intended audience through written materials (paper, electronic, etc.).
Teamwork	Interacting with others and building on each other's individual strengths and skills, working toward a common goal.
Information Processing	Evaluating, interpreting, manipulating, or transforming information.
Critical Thinking	Analyzing, evaluating, or synthesizing relevant information to form an argument or reach a conclusion supported by evidence.
Problem-Solving	Identifying, planning, and executing a strategy that goes beyond routine action to find a solution to a situation or question.
Management	Planning, organizing, directing, and coordinating one's own and others' efforts to accomplish a goal.
Assessment and Metacognition	Self- and peer assessment: Gathering information and reflecting on experiences to improve subsequent learning and performance. Metacognition: Thinking/Reflecting about one's thinking and how one learns and being aware of one's knowledge.

The effective implementation of POGIL required learners to understand and attend to the specific process skills while working through the content material the POGIL activity was focusing on. It was that critical learners have exposure and practice with future ready skills because of our increasingly complex, interconnected global society that requires us to not simply know, but also be able to apply what we know to changing situations (Quigley, 2019). Learners needed to be provided explicit instruction on process skill definitions and POGIL expectations for group dynamics. Learners also received feedback throughout the POGIL activities regarding group dynamics and content and at the conclusion of the POGIL activities using the ELIPSS rubric to help learners grow in their skill development.

Clear instruction on the POGIL process, roles and process skill expectations allowed for the successful implementation of POGIL with the group of learners. In addition to clear instruction prior to beginning POGIL, I took on the role of facilitator during the activities to help guide learners and support when necessary. The POGIL instructional framework and process allowed for reflection and growth for the learners as well as the teacher in both content knowledge and the specific process skill of interpersonal communication.

2.3 Change Idea and Timeline

During the 2020-2021 school year, I implemented the POGIL framework in my biology classroom in the Greensburg Salem School District. The POGIL framework allowed for learners to develop process skills with a specific focus on interpersonal communication and content knowledge due to purposeful group work, specific feedback, and focused reflection. Although there was a specific focus on interpersonal communication, the POGIL process has the possible to focus on eight different process skills – information processing, critical thinking, problem solving, interpersonal communication, written communication, teamwork, management, and metacognition. The POGIL process and activities allowed learners to experience content and skills in a collaborative and supportive class structure. The POGIL framework allowed for curriculum pacing to be maintained while meeting the needs of learners.

For the purposes of this initial study cycle, interpersonal communication was the focus skill for development with learners. Interpersonal communication skill development was identified as a need for Greensburg Salem learners via interviews and surveys conducted with Greensburg Salem teaching staff during the 2019-2020 school year. During, future research cycles I had planned to focus on additional process skills – critical thinking, information processing, and teamwork.

The analysis of the effectiveness of POGIL was a mixed-method study over multiple academic units of study. In addition to the POGIL activities, learners received initial instruction and continuous feedback on the POGIL process, roles, and skill focus. Table 7 outlines the overall structure of the implementation of POGIL within a high school biology classroom which included the direct instruction on the POGIL framework as well as learning opportunities. The POGIL intervention timeline included the activity to be implemented and the duration.

Table 7. POGIL Intervention Timeline

<table>
<tr><td>Topic</td><td colspan="3">Introduction Days</td><td>Content Study Days</td></tr>
<tr><td>Month/Year</td><td colspan="3">December 9th, 10th,
and 11th 2020</td><td>December 2020</td></tr>
<tr><td>Activity</td><td>POGIL Process</td><td>POGIL Roles</td><td>POGIL Skills</td><td>Unit 6 – Cellular Division
December 8th Pre Content Form
December 14th POGIL on Cell Cycle
December 15th Group Meetings
December 17th POGIL on Mitosis and Meiosis
December 18th Group Meetings
December 21st Post Process Skill and Content Forms</td></tr>
<tr><td>Duration</td><td>1 Day</td><td>1 Day</td><td>1 Day</td><td>1 Week
2 POGILs</td></tr>
</table>

Prior to the beginning of the unit of study, learners received specific instructions on the POGIL framework which included the overview of the process, group roles, and the process skill of interpersonal communication. The unit of study (cellular division) that was selected for the content study days was a unit that is typically difficult for learners due to the pacing, rich content, and volume of material.   Learning about cell division, growth and reproduction is a part of the core of science and technology that is vitally important to the future health implications and is pertinent to any student taking the course. The unit of study selected for this study connects with the biology big idea that new cells arise from the division of pre-existing cells. There were two POGIL activities – POGIL on Cell Cycle and POGIL on Mitosis and Meiosis – completed during the unit of study. In addition to the POGIL activities and ELIPSS rubric assessments, the units of study included content presentations (mitosis and meiosis notes), content practice work (Labster on Cell Division, Labster on Meiosis, and cell division Escape Room), and content assessment (pre-post cell division unit assessment). Throughout the course of the units, learners were consistently exposed to content related to the unit topic while focusing specifically on interpersonal communication skill development during the POGIL activities.

Prior to beginning the POGIL activities, learners were assigned specific groups and specific group roles. The roles and expectations of the POGIL framework were reviewed. In addition to the group and role focus, learners were provided with a description of interpersonal communication. All groups will receive role expectation cards (see Appendix I) and a description card on interpersonal communication (see Appendix J). During the POGIL activities, I circulated the room to perform learning checks as well as skill development redirection related to the group roles as well as use of interpersonal communication. The POGIL activities (see Appendix G and Appendix H) provided learners the opportunity to explore content through models and questions. While the POGIL process provided learners with a collaborative learning structure to develop and practice interpersonal communication skills. Each POGIL activity had key concept check points built in (indicated on the activity with a key symbol) and stop check points built in (indicated on the activity with a stop sign). At the key concept and stop check points, groups consulted with me to ensure content answers were accurate and the group role dynamics as well as skill focus requirements were being fulfilled. During those check points, I provided content and process feedback to learners using the POGIL teacher guide (content) and ELIPSS rubric (process). At the conclusion of each POGIL activity, I set up meetings with each group of learners to discuss feedback using the ELIPSS rubric (process). Each group also received content specific feedback on the graded POGIL activities.

During the implementation of the POGIL framework in my high school biology classroom, I focused on the following inquiry research questions:

- How and to what extent did the learners use interpersonal communication in their learning?
    - How did learners describe their interpersonal communication in their learning?
- How does supporting learner use of interpersonal communication influence learner content achievement?
    - How does the structure of my classroom impact the facilitation process of the POGIL activities?

The primary inquiry questions had a focus of building learner content knowledge while increasing learner use of interpersonal communication skills and improving classroom instruction. The secondary inquiry questions had a focus on learner and professional reflection. The prediction was that learners would increase their use of interpersonal communication as well as content knowledge over the course of the POGIL activities, indicating a positive impact of the POGIL framework on their high school biology learners.

2.4 Methods, Measures and Data Analysis

A mixed-methods approach was used to evaluate the implementation of POGIL in my biology classroom. Data was collected to assess how the implementation of POGIL influences learner use of interpersonal communication to support their learning as well as the influence on content learning achievement. The entire implementation process occurred over the course of one unit of study and approximately a week and a half of time within the semester high school biology course. The learner sample group included three blocks of learners, 68 learners total.

2.4.1 Participants

The study group included three class rosters of high school biology learners that are assigned to my roster. The class rosters included a mixed group of learners with range of content backgrounds and abilities. For the purposes of the POGIL framework, learners were divided into groups of 3-4 learners. The groups were created using the randomization group feature in the Beedle application found within the district password protected Microsoft Teams account. The groups remained the same over the course of the unit of study. Although the group assignments were randomized in Beedle, the role assignments were not. Learners that were not engaging in the curriculum at the time of the study were sorted from the Beedle application before the randomization of the groups.

For the purposes of group assignments, I randomly assigned block letters (A, B, C) relating to my three class blocks and assigned (alphabetical and numerical codes, ie. A2) to all learners. Also included in the tables is information about Sex (F for Female or M for Male) and specially designed instruction status (GIEP for Gifted Individualized Education Plan, IEP for Individualized

Education Plan, or RE for Regular Education Instruction). In addition to the active learner groups that participated in the study, the tables also note learners who did not engage in the study or course instruction throughout the fall 2020 semester. The ideal group size for POGIL activities was four learners due to the role assignment. The tables include information about role assignment for each learner – manager (M), recorder (RC), Presenter (P), and Reflector (RF). The manager helped the group stay on track with the activity by reading questions to the group, promoting group members participation, monitors time, and asks questions for the group to the facilitator (instructor/teacher). The recorder completed answers for the group on the activity worksheet. The presenter presented oral answers to the facilitator when asked for checkpoint reports and responds to questions prompted by the facilitator. The reflector reflected on overall group progress through the activity during the group reflection meetings (Simonson, 2019). The role assignments were purposeful for both regular education and special education learners. For regular education learners, I based my role assignments based on observed strengths as well as needs which were observed throughout the early part of the fall 2020 semester. For the learners with IEPs, their assignments related to their IEP goals which focused on written communication, self-regulation or self-advocacy/verbal communication.

There were 55 learners or 81% of my roster that actively participated in the implementation cycle while 13 learners or 19% of my roster did not actively participate in the implementation cycle. The learners that are defined as not actively participating or engaging in the implementation cycle are learners that did not log in for class and did not complete any of the cycle steps. There were 14 total groups of active participates and three groups of learners that did not engage with the curriculum or instruction during the fall 2020 semester. Each of the 14 groups was observed twice during the POGIL implementation cycle. Each of the 14 groups was met with twice during the POGIL implementation cycle for group feedback. Appendix K highlights the group assignments for each block (A, B, C) based on learner assignment, descriptive information (General Education (GE), 504 Plan (504), Individualized Education Plan (IEP) or Gifted Individualized Education Plan (GIEP) learners) and assigned POGIL role (manager (M), recorder (RC), Presenter (P), and Reflector (RF).

In Block A, there were 24 total learners with 66% of the roster actively engaging in the implementation cycle and 33% of the roster not engaging in the implementation cycle. There were four total groups with four learners per group. Learners A15 and A19 had a goal in their IEP that connected with written communication. Learners A16 and A20 had a goal in their IEP that related to improving self-advocacy and verbal communication. The eight learners that did not participate were offered the opportunity and necessary resources but did not engage in class (did not log in for class and did not complete assignments). Of the 33% of the roster that did not engage, 63% were learners with IEPs.

In Block B, there were 17 total learners with 94% of the roster actively engaging in the implementation cycle and 6% of the roster not engaging in the implementation cycle. There were four total groups with four learners per group. Learners B4 and B8 had a goal in their IEP that connected with written communication. Learner B2 had a goal in their IEP that related to improving self-advocacy and verbal communication. Learner B6 had goals in their IEP that related to self-regulation/positive behavioral reinforcement. The learner that did not participate was offered the opportunity and necessary resources but did not engage (did not log in for class and did not complete assignments).

In Block C, there were 27 total learners with 85% of the roster actively engaging in the implementation cycle and 15% of the roster not engaging in the implementation cycle. There were six total groups with at least three learners per group. Learners C14 and C26 had a goal in their IEP that connected with written communication. Learners C5 and C24 had a goal in their IEP that related to improving self-advocacy and verbal communication. Learners C8 and C12 had goals in their IEP that related to self-regulation/positive behavioral reinforcement. The learner that did not participate was offered the opportunity and necessary resources but did not engage (did not log in for class and did not complete assignments).

2.4.2 COVID Impact

The COVID-19 Pandemic interrupted the original structure of the change idea and timeline because our district was totally remote at the time of the change idea and data collection period. Although the study occurred in a totally remote structure, I was able to maintain the number of classes within the study. The hybrid and remote learning structure due to COVID-19 impacted my course pacing throughout the entire semester, therefore, the decision was made to decrease the number of units covered within the study (one unit of study instead of three units of study). The decrease in the number of units of focus will allow flexibility with the curriculum pace being shifted due to the complications of online learning.

Due to the shift to remote instruction by the district, all components of the study (instruction, group work, observations, collection of data pieces) were completed virtually via the password protected Greensburg Salem Microsoft Office 365 Suite applications and the password protected class meetings via the ZOOM application. The observation component of the study included only virtual observations via the password protected Greensburg Salem Microsoft Office 365 Suite applications and ZOOM application. The group meetings to provide feedback occurred via virtual meetings through use of the password protected Greensburg Salem Microsoft Office

365 Suite applications and ZOOM application. All group meetings that occurred were scheduled the day prior with learner groups. Due to a school district policy and school district solicitor input, the group work, observations and meetings that occurred virtually were not recorded and learners could select whether or not they wanted to appear on screen. Although cameras were optional, all learners were required to be unmuted and participate in the class discussion.

2.4.3 Measures

The data sources were a combination of pre/post data sources (process skill and content), completion of Enhancing Learning by Improving Process Skills in STEM (ELIPSS) rubric evaluations of learners during POGIL activities, and teacher reflection journals. Table 8 further outlines the related inquiry questions and corresponding forms of data. The types of measures in Table 8 include outcome (leading and lagging), process, driver and balance measures.

Table 8. Data Sources for POGIL Implementation

<table>
<tr><td colspan="2">Inquiry Questions:
• How and to what extent did the learners use interpersonal communication in their learning?
○ How did learners describe their interpersonal communication in their learning?</td></tr>
<tr><td>Data Source</td><td>Type of Measure</td></tr>
<tr><td>Post Process Skill Data Source
ELIPSS Feedback Rubric
Teacher Reflection Journal</td><td>Outcome
Process
Process & Driver</td></tr>
<tr><td colspan="2">Inquiry Questions:
• How does supporting learner use of interpersonal communication influence learner content achievement?
○ How does the structure of my classroom impact the facilitation process of the POGIL activities?</td></tr>
<tr><td>Data Source</td><td>Type of Measure</td></tr>
<tr><td>Pre/Post Content Data Source
Teacher Reflection Journal</td><td>Balance
Process & Driver</td></tr>
</table>

Each of those types of measures were included to ensure the study design was well-balanced. The outcome (lagging and leading) measures were utilized to investigate what I was aiming to improve and the processes necessary to influence change. The process measures provided data on the progression of the change idea during implementation. The driver measures provided information on if the change idea was impacting the primary and secondary drivers which focused on learners and teachers. The balance measure was in place to determine whether the change idea was impacting other parts of my classroom system.

Over the course of the unit of study, there were two POGIL cycles. Each cycle included: one post process skill data sources (end), two pre/post content data sources (beginning and end), and ELIPSS feedback rubrics completed (POGIL One and unit POGIL Two activities). During the introduction days and throughout the course of the POGIL activities, I completed nine teacher journal entries.

The post process skill data source, pre/post content data source, and ELIPSS rubrics (feedback rubric) provided all learners with specific feedback on content and interpersonal communication. The teacher reflection journal was used throughout the course of the activities to note observations, successes and challenges with the process of implementing POGIL within the remote learning structure.

2.4.3.1 Pre/Post Data Sources of Learners

The unit post process skill data source (Post Learning Survey for Students) (see Appendix B) was constructed using both open ended and Likert scale questions to allow for participant feedback on the focus process skill and the POGIL experience. The post process skill data source (Post Learning Survey for Students) remained the same for all blocks. This data source was completed and collected at the end of the unit of study.

The pre/post content data source (see Appendix C) were constructed using the big idea from the unit on cellular division within the Biology curriculum and aligned to the POGIL big ideas covered throughout the learning experiences. The pre/post content data source remaining the same from the beginning to the end of the unit of study. This data source was completed and collected at the beginning and end of each unit of study.

2.4.3.2 ELIPSS Feedback Rubric

The Enhancing Learning by Improving Process Skills in STEM (ELIPSS) rubric evaluations of learners by the teacher during POGIL activities allowed for focused feedback on the process skill of interpersonal communication. For the purposes of this study, I used the PDF version of the interpersonal communication and interpreted the observations and provided feedback through my professional vantage point. There were no edits or alterations to the rubric made. The rubric provided learning groups specific quantitative and qualitative feedback regarding their progress through the POGIL activities. Appendix A showcases the structure of the feedback rubric used for the study (Cole et al., 2020). The ELIPSS rubric was supportive in helping to identify participants' progress with interpersonal communication over the course of the unit of study. The ELIPSS rubric was valuable to utilize throughout the study, however, they are skill specific and not broad. Each group was provided the rubric during the group meetings the following day and in between the POGIL activities to allow for reflection. The ELIPSS rubric on interpersonal communication focused on the exchanging of information and ideas through speaking, responding (listening and verbal response), and non-verbal behaviors. Speaking, the expression of information and ideas to others, was evaluated by observing the following characteristics – spoke loudly and clearly enough for all team members to hear; used a tone when speaking that invited other people to respond; language/expressions were suitable for the listeners and environment; and duration of speaking was effective for listener for listener or communication. Listening, the attention and focus paid to the speaker as information and ideas were communicated, was evaluated by observing the following characteristics – patiently listened without interrupting the speaker; turned attention to the speaker when they were speaking; and refenced others' ideas to indicate listening and understanding. Verbal response or responding, replying and reacting to the communicated information and ideas of others, was evaluated by observing the following characteristics – acknowledge other members of the group for their ideas or contributions; rephrased or referred to what other group members have said; asked other group members to further explain a concept; and elaborated or extended on someone else's idea(s). Non- verbal behaviors, use of productive body language while speaking, listening, and responding to promote communication, was evaluated by observing the following characteristics – used body language to indicate they were listening; avoided behaviors that others have indicated are distracting; and avoided engaging in activities that diverted from the learning task. In addition to the observed behaviors, the rubrics included rating scales 0-5 with 0 as no evidence, 1 as ineffectively/rarely, 2, 3 as adequately/sometimes, 4, and 5 as effectively/consistently. The rubrics also partnered suggestions for improvement with each rubric category. Learners received feedback on observed behaviors, rating scales, as well as suggestions for improvement.

2.4.3.3 Teacher Reflection Journal

The use of teacher journaling was be used to track issues or successes of implementation. A journal prompt (see Appendix D) was used to guide consistent reflection of POGIL processes. The journal entries were used to analyze interpersonal communication, learning cycle stages, and questioning advantages and disadvantages in classroom implementation.

2.4.4 Data Analysis

A mixed-methods approach was be used to evaluate the implementation of POGIL in my biology classroom through multiple sources of data. The data collected were analyzed through qualitative and quantitative means. All learner specific data was protected using a coding system where each learner name is replaced with an alphabetical/numerical code. All data sources and learner specific data was securely stored on my password protected computer and in a locked filing cabinet in my home classroom office. The key to the filing cabinet was stored in a separate hidden location in my home.

2.4.4.1 Pre/Post Data Sources of Learners

Both pre/post data sources (process skill and content) were developed to evaluate the change in understanding in both interpersonal communication and content knowledge over the course of the unit of study as well as multiple POGIL activities. The pre/post data sources were not compared to other units of study as those units did not follow the POGIL framework, however, the pre/post data sources were used to identify overall trends for each individual learner.

The post process skill data source (Post Learning Survey for Students) was analyzed through a coding system (see Appendix E) as well as an analysis for the Likert scale questions among learners. The coding system includes four categories: content, skill, process, and emotion. The post process skill data source was collected and analyzed using the Greensburg Salem School District Microsoft Office 365 Online Suite applications of Microsoft Forms and Microsoft Teams. Once analyzed, the post process skill data sources were securely archived and stored.

The pre/post content data source was analyzed using a teacher answer key that is securely stored. The pre/post content data source was collected and analyzed using the Greensburg Salem

School District Microsoft Office 365 Online Suite applications of Microsoft Forms and Microsoft Teams. Once analyzed, the pre/post content data sources were securely archived and stored. Learners received their individual copies of the pre/post content data source with feedback of both the pre- and post- content data source. The copies of the pre/post content data source were sent to groups and individual learners via their password protected Microsoft Office 365 Outlook accounts. The pre/post content data source was analyzed for percent change of content knowledge of the course of each unit of study.

2.4.4.2 ELIPSS Feedback Rubrics

The ELIPPS feedback rubric data was collected and analyzed using the password protected Greensburg Salem School District Microsoft Office 365 Online Suite applications of Microsoft OneDrive, Microsoft Excel and Microsoft Teams. The observations were completed via ZOOM by placing groups into virtual breakout rooms. The Microsoft Excel application and Microsoft OneDrive were used to organize the ELIPSS Analytic Rubric and Feedback Rubric outcomes during all sessions. Copies of the rubrics were sent to groups and individual learners via their password protected Microsoft Office 365 Outlook accounts. The ELIPSS rubrics were analyzed for change over time for the group as well as observations on individual learners.

2.4.4.3 Teacher Reflection Journal

The teacher reflection journal source was analyzed through a coding system (see Appendix E). The teacher reflection journal entries were collected and analyzed using the password protected Greensburg Salem School District Microsoft Office 365 Online Suite applications of Microsoft OneDrive and Microsoft Word. The teacher reflection journal data source was analyzed qualitative input over the course of the study.

3.0 PDSA Results

3.1 Results

This PDSA cycle of the POGIL framework found four majors results: the framework cycle positively impacted interpersonal skill development of learners, the cycle did not negatively impact learner growth in content material, learners noted that the POGIL framework allowed them to practice interpersonal communication, and the POGIL framework allowed my classroom instruction to shift from teacher-focused to student-centered. The POGIL framework allowed learners to engage with content material while practicing interpersonal communication skills. Relating to interpersonal communication skill development, 64% of the learner groups showed growth during the PDSA cycle with 50% of learner groups showing less than 10% growth and 14% of learner groups showing greater than 10% growth. There were 22% of learners on my teaching roster that there was no comparison data for growth/regression because they did not engage in the PDSA cycle. Although all learner groups did not achieve the aim of 10% growth, nine groups were evaluated to have grown over the course of PDSA cycle. Regarding content material growth during the course of the PDSA cycle, 96% of learners showed positive growth and 96% of learners showed greater than 10% positive growth. The PDSA cycle did not negatively impact content material growth as 0% of learners showed regression and 4% showed no growth or change. Although learners grow in both content knowledge and interpersonal communication, 0% of learner responses regarding learning content material specifically noted POGIL on the post skill data source, however, 32% of learners specifically noted POGIL as a group work strategy that allowed for the implementation and practice of interpersonal communication skills.

Purposeful instruction that focused on skill development through deliberately designed content activity opportunities allowed for individual learners to continue to grow and develop. The PDSA cycle also allowed for teacher reflection and growth regarding classroom environment and instructional patterns. The process shed light on the idea that learning as well as teaching connects more with growth than the focus on perfection. There always has been and will be a truly human element to classroom instruction strategies and engagement that was missing from the structure of my classroom ecosystem. The initial aim of the PDSA cycle was to increase both knowledge and use of interpersonal communication skills from individual learner baseline levels by 10% over the course of three units (approximately one month). The aim was modified to continue to focus on increasing both knowledge and use of interpersonal communication skills over the course of one unit of content.

3.1.1 Inquiry Questions

The primary inquiry questions focused of building learner content knowledge while increasing learner use of interpersonal communication skills and improving classroom instruction. The secondary inquiry questions focused on learner and professional reflection. The prediction was that learners would increase their use of interpersonal communication as well as content knowledge over the course of the POGIL activities, indicating a positive impact of the POGIL framework on their high school biology learners.

3.1.2 How and to what extent did the learners use interpersonal communication in their learning?

The POGIL framework broadly defined communication as written and oral. The definition of oral communication focused on exchanging information and understanding through speaking, listening, and non-verbal behaviors. The definition of written communication focused on conveying information and understanding to an intended audience through written materials. Although the POGIL framework and the implementation of the PDSA cycle required learners to communication via written and oral means, the PDSA cycle specifically connected with the oral communication piece of the POGIL framework.

The purpose of the ELIPSS Feedback Rubric on Interpersonal Communication data source was to serve as a process measure to monitor learner growth relating to process skill development during the implementation of the POGIL instructional framework. The ELIPSS Feedback Rubric helped provide learners with specific feedback regarding Interpersonal Communication on critical future ready and work place skills, such as improving ability to communicate with other people as well as ability to work in a team structure to problem solve. This process measure was in place to determine whether the change idea was impacting the process skill development in learner groups during the implementation of the POGIL framework.

3.1.2.1 ELIPSS Feedback Rubric on Interpersonal Communication

Regarding the initial aim of increasing skill development, the ELIPSS Feedback Rubric on Interpersonal Communication source was used to analyze the evidence for growth of learners with their groups regarding the process skill of interpersonal communication during the PDSA cycle. Although the POGIL activities involved process skill and content knowledge, the rubrics were used to observe, evaluate and provide feedback to learner groups specifically relating to interpersonal communication observable characteristics. All groups were observed and evaluated on speaking, listening, and responding, with only specifics groups that were observed and evaluated on non-verbal due to their computer cameras not being on. Tables 9, 10 and 11 highlight the percent change and learner group notes across the class blocks (A, B, and C), respectively.

The first POGIL experience (POGIL One) served as the baseline and the second POGIL experience (POGIL Two) served as the comparison. POGIL One percentages were found by observing learner groups during the POGIL on Cell Cycle and POGIL Two percentages were found by observing learner groups during the POGIL on Mitosis and Meiosis. Percentages were found for both POGIL One and POGIL Two by adding all of the category scores (speaking, listening, responding, and non-verbal). The percent change was found mathematically by doing the following calculation: [(POGIL Two % - POGIL One %)/POGIL One %]*100. Evidence for growth was indicated regarding percentages that were zero and above. Evidence for regression was not noted because no learner group percent changes indicated regression or negative growth. The N/E group included learners that did not engage in the PDSA cycle therefore there is no observation or comparison data for that group of learners.

Table 9. Summary of ELIPSS Feedback Rubric on Interpersonal Communication for Block A Groups – Fall 2020 – Regular Biology

Group	POGIL One %	POGIL Two %	Percent Change %	Summary Notes
Red	73	78	7	7% Growth
Blue	47	47	0	0% Growth
Orange	57	60	5	5% Growth
Yellow	65	70	8	8% Growth
N/E	None	None	None	No engagement

There were 16 learners or 66% of the Block A roster that participated in the POGIL framework and eight learners or 33% of the Block A roster that did not engage in the POGIL framework. Out of the four learner groups who engaged in the PDSA cycle, three groups (75%) showed positive percent change from the first to second POGIL learning experience. The positive percent change was an indication of growth. One group of learners who engaged in the PDSA cycle (25%) showed no percent change and no negative percent change as an indication of regression.

Table 10. Summary of ELIPSS Feedback Rubric on Interpersonal Communication for Block B Groups – Fall 2020 – Regular Biology

Group	POGIL One %	POGIL Two %	Percent Change %	Summary Notes
Red	53	70	32	32% Growth
Blue	67	80	19	19% Growth
Orange	78	78	0	0% Growth
Yellow	80	80	0	9% Growth
N/E	None	None	None	No engagement

There were 16 learners or 94% of the Block B roster that participated in the POGIL framework and one learner or 6% of the Block B roster that did not engage in the POGIL framework. Out of the four learner groups who engaged in the PDSA cycle, two groups (50%) showed positive percent change from the first to second POGIL learning experience. The positive percent change was an indication of growth. One group of learners who engaged in the PDSA cycle (50%) shown no percent change and no negative percent change as an indication of regression.

Table 11. Summary of ELIPSS Feedback Rubric on Interpersonal Communication for Block C Groups – Fall 2020 – Regular Biology

Group	POGIL One %	POGIL Two %	Percent Change %	Summary Notes
Red	46	46	0	0% Growth
Blue	47	50	6	6% Growth
Orange	75	76	1	1% Growth
Yellow	63	67	6	6% Growth
Green	50	50	0	0% Growth
Violet	75	75	0	0% Growth

N/E	None	None	None	No engagement

There were 23 learners or 85% of the Block C roster that participated in the POGIL framework and four learners or 15% of the Block C roster that did not engage in the POGIL framework. Out of the six learner groups who engaged in the PDSA cycle, three groups (50%) showed positive percent change from the first to second POGIL learning experience. The positive percent change was an indication of growth. Three groups of learners who engaged in the PDSA cycle (50%) shown no percent change and no negative percent change as an indication of regression.

Overall, the POGIL framework did not show indication of negatively impact learner growth relating to interpersonal communication skill development. The PDSA cycle included 14 learner groups (53 students) who were observed and evaluated based on interpersonal communication. Out of the 14 learner groups, nine groups (64%) showed growth during the PDSA cycle with seven (50%) of learner groups showing less than 10% growth and two (14%) of learner groups showing greater than 10% growth. The positive change over the course of the two POGIL activities was an indication for growth. There were 15 learners (22%) that there was no comparison data for growth/regression because they did not engage in the PDSA cycle.

The primary area of need for all learner groups relating to the ELIPSS rubric was responding which included suggested areas of improvement of: let team members know when they make a productive contribution, state what others have said in your own words to confirm understanding, ask a follow up question or ask for clarification, reference what others have said when you build on their ideas, and offer an alternative to what a team member said. Learner groups and individual learners were also frequently given the follow suggestions for improvement for speaking: speak audibly and clearly to your team members, carefully choose your words to align with the level of material, and speak for a length of time that allows frequent back and forth conversation. Regarding listening, learner groups and individual learners were frequently given the follow suggestions for improvement: allow team members to finish their thoughts and restate or write down what the previous speaker said to indicate that you were listening and understand their idea. Not all learners and learner groups were observed regarding the ELIPSS rubric category of non-verbal because learners were not required to have their cameras on. The learners that were observed and evaluated on non-verbal communication were frequently given the following suggestions for improvement: use active-listening body language (nodding, learning forward, following along with the task) and consider whether your behavior(s) may be distracting to others.

3.1.3 How did learners describe their interpersonal communication in their learning?

The purpose of the post skill data source was to serve as an outcome measure to analyze how learners viewed interpersonal communication after the implementation of the POGIL instructional framework. The outcome post skill data source was in place to analyze how learners viewed and described their interpersonal communication after the implementation of the POGIL framework. A pre-skill data source was not used as a comparison. The purpose of the post skill data source was not to measure growth during the POGIL instructional framework but to reflect and analyze learner responses relating to interpersonal communication.

3.1.3.1 Post Skill Data Source - Post Learning Survey for Students

Regarding the initial aim of increasing skill development, the post skill data source was used to analyze how learners viewed and described their interpersonal communication after the implementation of the POGIL framework. The post skill data source shown in Appendix B included four questions: one matching question on communication categories, one ranking question comfortable level relating to communication/interactive activities/group work, and two description questions focused on content activities and opportunities that related to practicing interpersonal communication. The responses included 19 learners or 35% of the learners who participated in the PDSA cycle.

The responses were analyzed quantitatively to examine: learner understanding of the evaluated categories of speaking, listening, responding, and non-verbal as well as levels of comfortable regarding communication, interactive activities, and group work. The forms of communication and their explanations were discussed when the POGIL framework was introduced to learners at the beginning of the PDSA cycle and twice during the PDSA cycle at each of the POGIL group meeting as they were the primary categories learner groups were evaluated on using the ELIPSS rubrics. All categories were reviewed with learners regardless of whether or not they were evaluated to ensure consistent conversations throughout the learner group meetings. In addition to the forms of communication, observable characteristics, suggestions for improvement, and quantitative ranking for the entire group were discussed during the learner group meetings. Figure 6 highlights the learner responses to the forms of communication and their explanations matching question on the post skill data source.

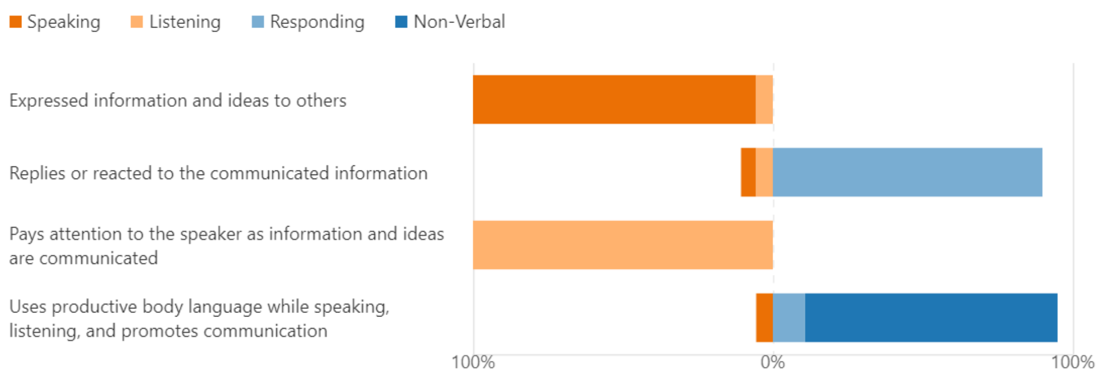

Figure 6 Communication Matching[6]

Speaking was defined by the ELIPSS rubrics as expressed information and ideas to others. The majority of learners (95%) identified the explanation of speaking accurately with 5% identifying the explanation as listening. Listening was defined by the ELIPSS rubrics as paid attention to speaker as information and ideas were communicated. The entire group of learners (100%) who completed the post skill data source identified the explanation of listening accurately. Responding was defined by the ELIPSS rubrics as replies or reacted to the communicated information. The majority of learners (90%) identified the explanation of speaking accurately with 5% of learners identifying the explanation as speaking and 5% of learners identifying the explanation as listening. Non-verbal was defined by the ELIPSS rubrics as uses productive body language while speaking, listening, and promotes communication. The majority of learners (84%) identified the explanation of speaking accurately with 11% of learners identifying the explanation as responding and 5% of learners identifying the explanation as speaking. Another aspect of the

[6] The forms of communication were evaluated during the PDSA cycle. Their explanations were used consistently in learner group meetings.

post skill data source focused on comfort level rankings relating to four statements. The statements related to interpersonal communication, interactive activities, and group work as those were the focus of the PDSA cycle. Figure 7 illustrates the learner responses to the statements.

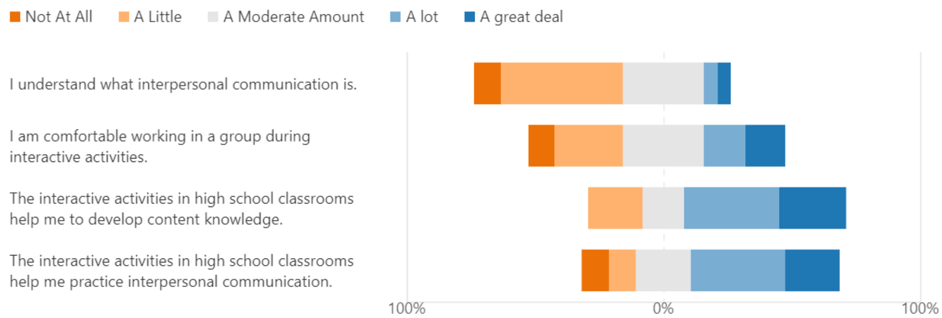

Figure 7. Comfort Level Questionnaire[7]

In response to the statement, I understand what interpersonal communication is, learners responded 11% not at all, 45% a little, 32% a moderate amount, 6% a lot, and 6% a great deal. Less than 50% of learners (44%) indicated they understood interpersonal communication a moderate amount and above. Relating to the statement, I am comfortable working in a group during interactive activities, learners responded 10% not at all, 26% a little, 32% a moderate amount, 16% a lot, and 16% a great deal. Over 50% of learners (64%) indicated they were comfortable working in a group during interactive activities. In response to the statement, the interactive activities in high school classrooms help me to develop content knowledge, learners responded 21% a little, 16% a moderate amount, 37% a lot, and 26% a great deal. There were no responses indicating "not at all." Relating to the statement, the interactive activities in high school classrooms help me practice interpersonal communication, learners responded 11% not at all, 11% a little, 21% a

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[77] Interpersonal communication and interactive activities were the focus of the PDSA cycle.

moderate amount, 37% a lot, and 21% a great deal. The majority of learners (79%) indicated that interactive activities help them practice interpersonal communication at a modern level or above.

The description responses were analyzed qualitatively using the Coding Tool in Appendix E to examine learner responses regarding content activities and interpersonal communication related activities within the high school setting. The description questions were analyzed for content, skill, process (strategy and procedure), and emotional connections. Table 12 summarized the results relating to the post skill data source for the 19 learners (36%) of participates that completed the post skill data source. All 68 learners on my roster were offered the opportunity to respond to the Post Skill Data Source (Post Learning Survey for Students), however, only 36% (19 learners) responded.

Table 12. Summary of Post Skill Data Source – Fall 2020 – Regular Biology

<table>
<tr><td colspan="3">Post Skill Data Source Descriptive Question One: Describe the activities in high school that help you learn the content material.</td></tr>
<tr><td>Code</td><td>Frequency</td><td>Percent Frequency</td></tr>
<tr><td>Content (CON)</td><td>5</td><td>26%</td></tr>
<tr><td>Skill (SKI)</td><td>7</td><td>37%</td></tr>
<tr><td>Process (PRO)</td><td>17</td><td>89%</td></tr>
<tr><td>Emotion (EMO)</td><td>2</td><td>11%</td></tr>
<tr><td colspan="3">Post Skill Data Source Descriptive Question Two: Describe how activities in school help you learn and practice interpersonal communication.</td></tr>
<tr><td>Code</td><td>Frequency</td><td>Percent Frequency</td></tr>
<tr><td>Content (CON)</td><td>2</td><td>11%</td></tr>
<tr><td>Skill (SKI)</td><td>8</td><td>42%</td></tr>
<tr><td>Process (PRO)</td><td>17</td><td>89%</td></tr>
<tr><td>Emotion (EMO)</td><td>4</td><td>21%</td></tr>
</table>

Learner responses for both questions often included more than one code. There were two learner responses relating to the post skill data source descriptive question two which were non-coding (response: sports and school clubs) as I did not think they fell into the content, skill, process or emotion coding categories. Relating to the first descriptive question that focused on content, there were 89% process, 37% skill and 26% content codes present in learner responses. Two responses (11%) associated with emotional responses of confidence and interest. 0% of learner responses regarding learning content material specifically noted POGIL as helpful for learning content material. In responses learners specifically noted the following activities as helpful for learning content material – problem solving opportunities (one response), student focused experiences (one response), teacher directed lectures (three responses), hands on learning opportunities (seven responses), individual assignments (one response), group work (five responses), assessments (two responses), and in person learning (one response). Relating to the second descriptive question that focused on interpersonal communication, there were 89% process, 42% skill, and 21% emotion codes were evident. In responses learners specifically noted the following activities as helpful for learning and practicing interpersonal communication – group/collaborative work (11 responses), student presentations (three responses), POGIL activities (six responses), hands on activities (three responses), and vocabulary focused work (two responses). Two learner responses did not specifically list activity types but noted any activity that forced you to actually do the skill and get out of their comfort zone. Regarding question two, 32% of learners specifically noted POGIL as a group work strategy that allowed for the implementation and practice of interpersonal communication skills.

Process related connections were made in the majority of responses (89%) for both questions. Process responses included group activities, presentations, readings, lectures, etc. and largely related to class procedures or instructional strategies. Skill related connections were made at the second highest percent frequency for both questions with question one having a 37% frequency and question two having a 42% frequency. Content codes had the third highest frequency for question one while emotion codes had the third highest frequency for question two.

3.1.4 How does supporting learner use of interpersonal communication influence learner content achievement?

The purpose of the pre/post data source was to serve as a balance measure to monitor learner growth relating to content knowledge regardless of the implementation of the POGIL instructional framework. The balance pre/post content data source was in place to determine whether the change idea was impacting other parts of my classroom system during the implementation of the POGIL framework.

3.1.4.1 Pre/Post Content Data Source

Regarding the initial aim of increasing content knowledge, the pre/post content data source was used to analyze learner growth regarding the biology content within the PDSA cycle. Table 13 highlights the patterns of growth and regression for all learnings across all blocks (A, B, and C).

Table 13. Summary of Pre/Post Content Data Source for All Blocks – Fall 2020 – Regular Biology

	A	B	C	Totals
# Positive Growth	14	16	23	53
# > 10% Growth	14	16	23	53
# Regression	0	0	0	0
# No Growth	2	0	0	2
# No Engagement	8	1	4	13
Number of Learners	24	17	27	68

There were 68 learners included in the fall 2020 semester with 19% or 13 learners not participating in the POGIL framework. The sample group included three regular biology courses. Out of learners who engaged in the PDSA cycle, 96% showed positive growth, 96% showed greater than 10% positive growth, 0% showed regression, 4% showed no growth or change, and

19% of the total number of learners on the roster were no takes (meaning they did not complete both the pre/post content assessment or engage in the PDSA cycle so there was no comparison data).

In addition to the POGIL activities and ELIPSS rubric assessments, the unit of study included content presentations (mitosis and meiosis notes), content practice work (Labster on Cell Division, Labster on Meiosis, and cell division Escape Room), and content assessment (pre-post cell division unit assessment). Overall, the POGIL framework did not negatively impact learner content knowledge growth. The POGIL along with the other unit activities enabled learners to grow in content knowledge from the beginning to the end of the unit.

3.1.5 How does the structure of my classroom impact the facilitation process of the POGIL activities?

The purpose of the teacher reflection journal was to serve as a process measure to monitor progression of the change idea during implementation of the POGIL instructional framework. The teacher reflection journal was also to serve as a driver measure to observe the impact of the change idea on the primary and secondary drivers which focused on learners and teachers during the implementation of the POGIL framework. The purpose of the teacher reflection journal was to reflect and analyze observations as well as successes and challenges within the process of implementing the POGIL framework. The journal was also used to reflect on the impact of the PDSA cycle on the primary (learner skill development) and secondary (teacher instruction) drivers.

3.1.5.1 Teacher Reflection Journal

In addition to the initial aim of increasing content knowledge, I also sought to increase my ability to teach and assess learners' future ready process skills in my high school biology classroom. The teacher reflection source was used to analyze and reflect on the impact of the PDSA cycle on my classroom ecosystem as well as instruction. Table 14 highlights the patterns of frequency relating to content, skill, process and emotion.

Table 14. Summary of Teacher Journal Coding

	Frequency	Percent Frequency
Content (CON)	9	100%
Skill (SKI)	9	100%
Process (PRO)	9	100%
Emotion (EMO)	5	56%

All nine journal entries connected with content, skill, and process relating to the implementation of the PDSA cycle in my class. There were five codes (33% frequency) that connected with emotions. The specific emotions noted were fear, confidence and pride. The early entries noted fear of implementation of a new framework during an already difficult year while the later entries noted noticing an increase in students' confidence levels and being proud of the student interest (engagement) with the process. Although not all learners or learner groups showed growth regarding interpersonal communication and/or content knowledge, those that did participate in the PDSA cycle were engaged and practicing with both content knowledge and skill. I noted the engagement piece of the POGIL framework as a success and indicated the online nature of the implementation as a true challenge. The online implementation of the PDSA cycle proved to increase the difficult of observing using the ELIPSS rubric in terms of non-verbal communication and moving between learner group breakout rooms instead of having a large view of learner groups working and engaging in the same space.

3.2 Conclusion

The initial aim was to increase both knowledge and use of interpersonal communication skills from individual learner baseline levels by 10% over the course of three units (approximately one month). During the impact of COVID-19 on many areas of instruction, my study was limited to one unit of study instead of three. The overall aim was to improve both teacher instruction (secondary driver) and learner skill development (primary driver), which were drivers identified in Figure 4.

The POGIL framework PDSA cycle positively impacted interpersonal skill development and did not negatively impact learner growth in content material. POGIL allowed learners to engage with content material while practicing interpersonal communication skills. Relating to interpersonal communication skill development, 64% of the learner groups showed growth during the PDSA cycle with 50% of learner groups showing less than 10% growth and 14% of learner groups showing greater than 10% growth. There were 22% of learners on my teaching roster that there was no comparison data for growth/regression because they did not engage in the PDSA cycle. Although all learner groups did not achieve the aim of 10% growth, nine groups were evaluated to have grown over the course of PDSA cycle. Regarding content material growth during the course of the PDSA cycle, 96% of learners showed positive growth and 96% of learners showed greater than 10% positive growth. The PDSA cycle did not negatively impact content material growth as 0% of learners showed regression and 4% showed no growth or change. Although learners grow in both content knowledge and interpersonal communication, 0% of learner responses regarding learning content material specifically noted POGIL on the post skill data source, however, 32% of learners specifically noted POGIL as a group work strategy that allowed for the implementation and practice of interpersonal communication skills.

My ability to teach and assess learners' future ready process skills in my high school biology classroom grew during the process of the PDSA cycle. I was able to grow in my fear of implementing change ideas in a classroom ecosystem held accountability by standardized measures and grow in my confidence to allow students to spend more time in content dialog with their peers. The PDSA cycle was enlightening as it reinforced the notion that classrooms can be infused with instructional methods and learning opportunities that pattern skill development and content knowledge practice. The PDSA cycle promoted growth in learners as well as myself as we were all involved in the process together, and as the old Chinese proverb says, "tell me and I will forget, show me and I may remember, involve me and I will understand."

4.0 Learning & Actions

4.1 Discussion

My problem of practice is that my learners are not learning and growing to their fullest potential in both content and necessary future ready skills – 21st century and process skills to prepare them for postsecondary life outside of my classroom. I teach many high school learners with exceptionalities. I sought to alter my instruction and ensure that learners' learning opportunities were meaningful, my aim is to improve my ability to teach and assess learners' future ready process skills in my high school biology classroom.

Complicating matters, prior to the PDSA cycle, I did not have access to instructional tools and assessments that would reveal whether and to what extent learners were learning rich future ready practices. Thus, my teaching cycle of planning, instruction, assessment, and reflection revolved mostly around learners' mastery of biology content material. My classroom environment was dominated by teacher-led direct instruction and lectures to transmit a large body of scientific knowledge in a limited amount of time. This general problem was shared by my colleagues in our science department and other professionals in the field (Tanner, 2004; Anderson, 2017) in that we did not consistently use rigorous or responsive instructional strategies or appropriate assessments to increase learners' 21st century skills and future ready competency skills.

During this study, learners were exposed to future ready skills in activities using the POGIL (Process Oriented Guided Inquiry Learning) framework. Through the purposefully planning, development of classroom norms and the implementation of effective learning experiences (driver one: teacher instruction), a classroom learning ecosystem was developed to ensure learners develop process skills (driver one: learner skill development) while growing in their content knowledge. Other drivers were also impacted such as learning environment (engagement strategies) and professional learning (professional development/reflection). The study allowed for classroom learning to align with both content and future ready requirements of the Every Student Succeeds Act of 2015 (federal policy impact) and Pennsylvania Future Ready Index state policy impact). The unit of study (cellular division) that was selected for the content study days was a unit that is typically difficult for learners due to the pacing, rich content, and volume of material. Learning about cell division, growth and reproduction is a part of the core of science and technology that is vitally important to the future health implications and is pertinent to any student taking the course. The unit of study selected for this study connects with the biology big idea that new cells arise from the division of pre-existing cells. There were two POGIL activities – POGIL on Cell Cycle and POGIL on Mitosis and Meiosis – completed during the unit of study. The specific future ready process skill of focus for this study was interpersonal communication. In addition to the study allowing for future ready skill infusion in content related activities, learners were able to practice thinking, feeling and communicating within a discipline instead of merely learning the information. Learners were able to practice meaningful skills with a focus on interpersonal communication while constructing and practicing content knowledge.

The PDSA cycle called for small scale change in an improvement cycle. Too often the changes made in my classroom failed to bring about effective change and positive improvement which correlates with most of the education patterns in history as James Hiebert, Ron Gallimore, and Jim Stigler cite, "The history of American education includes a graveyard of good ideas condemned by pressure for fast results (Bryk, 2016)." Although brief, the PDSA cycle did not place pressure on fast results and the process was valued far more than a standardized outcome. I was able to plan based on informed research, test my theory of improvement, study the results, and plan further classroom implementation cycles in a short amount of time. Although the PDSA cycle was helpful in small scale change and showed evidence for positive impacts on my classroom, I do believe the PDSA cycle and POGIL framework would more effectively be implemented consistently over the course of a semester class so further routines and feedback could be provided as well as more detailed observations could be made. Further observations and feedback could allow for more detailed reflection for refinement in future PDSA cycles.

The PDSA cycle structure and the focus of the POGIL framework could be implemented in any classroom with any group of learners to engage the human element in our classrooms with critical knowledge. The POGIL framework and ultimately mindset can be used to cultivate a comfortable, engaging learning ecosystem from the first to the last day of instruction. The POGIL framework for design/selection of activities to implementation of the process within a classroom also draws connections to stages of inquiry (exploration, invention and application), process patterns (orientation, induction, and deduction), and education goals (data acquisition, patterns observations, and higher-level thinking). In addition to the stages of inquiry, process patterns, and education goals, the POGIL framework allows for connections to be made consistently throughout the implementation process to Bloom's Taxonomy levels (Evaluation, Analysis, Comprehension, Synthesis, Application, and Knowledge). When used consistently and frequency throughout the timeline of a course, POGIL promotes growth and development in both content and skill development in many ways. A weakness for the POGIL project and framework is that activities are currently only formally published for anatomy/physiology, biochemistry, biology, chemistry, engineering, mathematics, computer science, and psychology. Another weakness of the PDSA cycle and POGIL framework was that it takes time to scaffold and implement. Another weakness is that POGIL activities are currently only published for … I do believe the PDSA cycle and POGIL framework should be implemented throughout the fabric of the course instruction and social dynamic to truly continue to gain fruitful results, continued practice and growth in learners. The overall PDSA cycle was challenged with the learning and teaching in a COVID shaken world. The transition to online learning impacted student engagement and level of motivation toward coursework. There was an observed shift in apathy levels before, during and after the PDSA cycle.

During the PDSA cycle, learners were evaluated and provided feedback on interpersonal communication using the ELIPSS rubric. For the purposes of this study, I used the PDF version of the interpersonal communication and interpreted the observations and provided feedback through my professional vantage point. There were no edits or alterations to the rubric. The rubric provided learning groups specific quantitative and qualitative feedback regarding their progress through the POGIL activities. The Enhancing Learning by Improving Process Skills in STEM (ELIPSS) rubric evaluations of learners by the teacher during POGIL activities allowed for focused, organized, and consistent feedback on the process skill of interpersonal communication. The ELIPSS rubrics are both descriptive in feedback and evaluative in quantitative nature which allowed learners and learner groups to reflect on progress made relating to interpersonal communication. The rubric provided indicators of learning performance relating specifically to the areas of interpersonal communication. The indicators of learning were divided into multiple sections so the rubric was analytical (provides feedback and evaluation within multiple areas) and not holistic (summarizing performance with a single score) in nature. The ELIPSS rubric was developed by the project collaboration team at the ELIPSS Project which includes 11 education professionals. The project collaboration team features a group of post-secondary professionals that are majority Caucasian and female. There are not specific details about the development and publication process relating to the ELIPSS project, however, the surface information provided serves as a reminder that cultural bias could exist within the rubrics. Although rubrics are published by the ELIPSS Project – subscribers can access PDF and Excel versions of the rubrics. The PDF version can be used as published and interpreted by the user. The Excel version can be edited to allow flexibility within the instructional context. The cultural connections made in the Interpersonal Communication rubric could impact learners negatively in their learning experience if they are not from the dominant culture. For example, the speaking portion of the rubric calls on learners to use specific tone, language selection and appropriate speaking length; the listening portion of the rubric calls on learners to maintain eye contact and restate previous speakers ideas; the responding portion of the rubric evaluates learners on their contributions to discussion as well as asking follow up questions; and the non-verbal portion of the rubric provided feedback to learners on their ability to maintain eye contact, face group members, learning toward group, and consider distractive behavior – all of which could vary based on cultural and ethnic background. It is important to note that educators using the ELIPSS rubrics need to reflect and implement the rubrics with edits depending on their classroom demographics as well as the needs of individual learners. Educators that are aware of the background of their learners and who listen actively to discussions relating to culture can modify the rubrics to be more responsive and purposeful for all learners, not just the learners accustomed to the mainstream culture. The main purpose of the ELIPSS rubrics is to assess performance of the specific skill and provided feedback. If learners are not members of the dominant or mainstream culture and accustomed to the cultural norms that the mainstream POGIL framework roles/group dynamics are centered around and that are presented within the rubric, the learners could have an undesirable or indifferent experience relating to the POGIL framework and ELIPSS rubrics due to lack of appropriate feedback. In addition to reflecting on the cultural bias within the ELIPSS rubrics, I also believe it important to be mindful of the influence of teacher bias and perspective in evaluation of learners using rubrics like the ELIPSS rubric. My assigned roster was predominantly tenth grade learners (96%), male (53%), English language speaking (100%), and Caucasian/white (75%). There were 34% of learners on my roster identified to receive specially designed instruction relating to their IEP status with the remaining 66% of learners receiving general education instruction. Of the 34% of learners with an active IEP status, 39% were female and 61% were male. 61% of learners with IEP status were identified as Caucasian/white. My roster included 68 total learners with 46% being self-identified as living at or below the poverty level. All blocks were scheduled as a regular biology course within the Greensburg Salem School District. Although I recognize the ELIPSS rubric as well as the evaluation of learners connect with dominant cultural bias, I do not feel the cultural bias relating to appropriate social norms within the framework or rubric negatively impacted my learners during the PDSA cycle. Also, if there was biased in my evaluation of learner groups, the biased would have remained consistent throughout the PDSA cycle. The feedback provided to learners was consistently framed as areas of grow in and successes were highlighted as well. Due to the possible rubric and evaluation bias, I do feel that it would be beneficial to implement the POGIL framework within a coteaching environment so both educators could provide specific and detailed feedback to learner groups as a pair. If a coteaching environment is not possible, collaboration and reflection with another professional would be beneficial to ensure that the needs of all learners are being considered.

In many ways, the PDSA cycle validated my vision of future ready learning in that future ready instruction needed to include a partnership of content and skill development within a classroom that was learner-centered, problem-solving focused, and rigorous. Many supporters of future ready learning experiences and process skills noted learner development of content knowledge and future ready/21st century skills such as collaboration, problem-solving, critical thinking, and communication through learner-centered experiences are critical in science education which the POGIL framework allowed (Basham, 2013; Guzy, 2017; Israel, 2013; Hansen, 2014; Herro, 2016; Quigley, 2016/2017). After reflecting on my instructional practices as well as the PDSA cycle, I believe that I can more effectively implement future ready instructional methods such as cooperative learning groups, creative problem-solving strategies, and variation in scientific knowledge presentation. The POGIL instructional framework allows for a union of content knowledge development with process skill focused assessments. In order to meet the needs of our learners, the implementation of effective assessment strategies to evaluate both content knowledge and future ready skills was and still is necessary. Although the structure of accountability at a state and federal level appears to not be changing, I impacted learning by shifting my classroom framework to include collaborative, inquiry approaches as well as mixed method assessment structures that partnered traditional and non-traditional forms of assessment/feedback.

Under The Every Learner Succeeds Act (ESSA) of 2015, the state of Pennsylvania launched a framework for holding schools accountable. Within that framework, the Future Ready Index served as a measure of the school learning climate. The Future Ready Index (FRI) identified achievement goals for content growth and mastery, graduation rates, post-secondary transitions to career/school/military, and AP exam achievement for different subgroups of learners. In addition to the FRI, Pennsylvania enacted Act 158 which provided alternative pathways to graduation. Although the state recognized the importance of both postsecondary skills and content knowledge, the biology curriculum at a state and local level was largely focused on content knowledge mastery.

The standards and eligible content did not explicitly recognize that our classrooms were situated within schools that have their own cultural identities, climates, and needs. Our schools were embedded and operating within district systems that were focused on initiatives and accountability demands while aiming to help our learners grow (Biag, 2017). Through the attainment of more knowledge about the practices and assessment strategies for future ready learning in biology that equated to the effective pairing of content exploration and skill development, the instruction and assessments within my classroom improved learner content mastery along with future ready competency skills in Biology for all learners. Although learning strategies and assessments were altered, my curriculum scope and sequence achieved the requirements of local, state and federal standards.

4.2 Next Steps & Implications

Based on the outcome of the study, I plan to conduct another cycle of change with the fall and spring 2021-2022 cohort of learners where we will utilize the same POGIL framework to investigate the same process skill of interpersonal communication and content material. The fall 2021-2022 cohort of learners will be a different group of learners than the spring 2021-2022 cohort of learners due to the semester, block structure of classes in the Greensburg Salem School District. After the 2021-2022 cycle, I plan conduct another cycle the following year focusing on a different process skill. The next process skill identified as a need for our learners is critical thinking. Although I plan to focus on different process/future ready skills, I do plan to implement the POGIL framework and instructional mindset from the beginning to end of my courses to scaffold and reinforce the process throughout all instructional activities not just simply the POGIL activities.

The continued cycles of study will hopefully continue to show indication that purposeful instruction on the POGIL process and future ready process skills will increase learner content knowledge as well as use of process skills. The study will hopefully continue to show indication that learners can learn to effectively and efficiently utilize future ready process skills to complete content activities in small peer groups. Also, the study will hopefully continue to indicate a correlation between an increase use of process skills and an increase performance academically.

In addition to shifting my instruction with students, my mindset with engaging with other professionals has shifted and I would like to develop a professional development opportunity for my district for all 7-12th educators that are instructed. The professional development opportunity would offer instruction on fundamentals of POGIL, group formation options within POGIL, writing POGIL activities, and classroom facilitation. The opportunity would allow professionals within my district to hear about POGIL and then work to implement the POGIL framework within their classrooms. After the professional development workshop, I would continue to serve as a collaboration member for the staff within my district. There have been calls to transition our instruction to a more student-centered approach, based on the findings that inquiry-based instruction tends to result in better academic outcomes than that of traditional instructional techniques (Ferguson, 2010). Methods to increase student engagement in mathematics and science classes find that engaging students to develop their own understandings and connections is one of the most difficult aspects of instruction (Boaler, 2018). The POGIL framework facilitates higher-level thinking while promoting collaboration can be modeled within any content classroom and level of instruction. POGIL not only involves students growing in content knowledge, but it also promotes future ready skills such as communication (verbal and written), critical thinking, teamwork and problem-solving skills. The professional development opportunity would be beneficial as my district moves toward active learning instructional methods to provide support to educators throughout. POGIL encourages learners to collaborate in teams while building content knowledge as well as skills, however, without proper development of the activities, implementation of the framework, and continued support of learners the framework will not work effectively. By supporting my fellow educators, the district can build more instructional tools to support learners with both the content knowledge and the skills needed to successfully enter post-secondary studies, higher education, or the work force.

5.0 Reflections

5.1 Professional Reflection

As Ron Edmonds reminded us, "We can, whenever and wherever we choose successfully teach all children whose schooling is of interest to us; we already know more than we need to do that," the PDSA cycle reminded me that knowing something is important (content and process skills) is not the same thing as knowing how to make it happen well on a regular and consistent basis within our classrooms (Bryk, 2016). Throughout the course of the fall semester and implementation of the PDSA cycle, I was frequently reminded that teaching has nothing to do with perfection and everything to do with growth. The process of instruction and learning should be just as valued as the outcome of instruction and learning. I was also increasingly aware of the need to recognize and include the human element in my classroom ecosystem. Students, teachers and classroom alike are not interchangeable and cannot be engaged as such. Students, teachers, and classrooms were directly impacted by the COVID-19 pandemic and standardized measures stresses prior to COVID-19. The PDSA improvement science cycle allowed for focus to be drawn from standardized accountability structures and focus on specific tasks (POGIL activities); useful processes and tools (POGIL framework and resources; ELIPSS rubric); how prevailing and consistent policies impact my classroom (Bryk, 2016). The framework also allowed for an engaging dialogue to occur between learners and between learners and their teacher in a time where the human aspect of interacting with others was limited due to social distancing and remote learning measures. I believe I had many successes within my PDSA cycle and the implementation of the POGIL framework within my classroom. The framework allowed for increased engagement and student dialogue, student exploration of content material through a varied instructional platform, presentation of difficult content material through visual model analysis, and practice of future ready skills with a specific focus on interpersonal communication. I was able to implement an effective, efficient and engagement instructional framework when for years, I was very uncomfortable with unstructured dialog and had a fear of falling out of pace with curriculum guidelines. There was the always and still is the ever-hovering stress of standardized testing and professional evaluation measures at a local, state, and federal level, however, this study and entire COVID-19 2019-2020 and 2020-2021 school years helped me realize that learners need instructional environments where they engage with others and where they explore the content.

Although COVID-19 impacted student engagement, I do not believe the lack of participation by students would be alternated in a non-COVID school year so I do believe the impact of the PDSA cycle would remain consistent. I do believe the POGIL framework would be more effective and efficient if implemented throughout the course from beginning until end because there would be extended practice with the procedures, group roles, focus skill, observations, and feedback. The implementation over the course of a year would allow educators to increase their observation time with each group and provided more specific feedback over an extended timeline instead of a brief snapshot. There was a long-standing assumption in the back of my head that teacher direct instruction allowed for pacing as well as student learning, however, teacher direction instruction does not guarantee engagement, growth or mastery. Although the impact of policy still persists, I realize that there is space in my classroom environment to allow for flexibility in instructional strategies to promote learning content mastery while practicing critical future ready skills. Although there were positive impacts felt and successes experienced with the PDSA cycle within my classroom, I do believe there are challenge areas when implementing POGIL. A critical piece of the POGIL framework is implementation of groups and group roles. The POGIL framework itself allows for flexibility in the set up of groups (randomization, specific role assignments based on strengths or areas of need, student selected groups, etc.). For the purposes of my study, groups were randomly assigned and I did not observe negative group dynamics during the PDSA cycle, however, I believe the structure of the group and the dynamic of the group could have impacted progress and achievement during the activities. Educators implementing the POGIL framework need to pay special attention to group dynamics during the initial implementation of POGIL groups. Student engagement and attendance could impact the progress and achievement of the POGIL groups as well. Flexible and observant implementation of the POGIL framework would allow educators to be responsive to individual student concerns and group dynamic challenges that arise.

The PDSA cycle showed that small focused cycles of purposeful instruction can ensure both future ready process skills, such as interpersonal communication, and content knowledge standards are being addressed in my high school Biology classroom. The PDSA cycle and focus of improvement science mirrors the work I was informally doing within my professional teaching role for years. The planning (questioning and forming predictions), do (inquiry steps), study (results and observations), and act (professional reflection) are primary components of our lesson planning and unit planning structure so I am encouraged to continue the PDSA cycle in a small way on daily, weekly, monthly and semester way. The PDSA cycle promotes well-informed, small tests of change that allow for what I would previously define as professional failures and re-envisions those failures as opportunities for growth. The process is just as important as the outcome which was not my personal or professional operating mentality.

Through the PDSA cycle, there were many curriculum theory angles involved – scholarly academic, social efficiency, and learner centered. My instructional pattern for years had focused largely on scholarly academic and social efficiency. The scholarly academic portion of my instructional style had focused on the transmission of academic knowledge with the realization that learners were expected to learn standardized content and be evaluated through standardized measures at the conclusion of my course. The social efficiency portion of my instructional style had focused on skills development through classroom procedures, routines, and sequence of instructional activities. The process allowed my instructional patterns to shift. The PDSA cycle still included my prior focus on scholarly academic and social efficiency except the social efficiency curriculum focus shifted to the POGIL framework and future ready skill development through instructional activities not solely classroom procedure related. The PDSA cycle also shifted my classroom vision to learner centered, where learners were able to engage in enjoyable engagement opportunities while focusing on skills, content and growth. Learners were provided content focus as well as individualized growth feedback regarding interpersonal skill development. Purposeful instruction that focused on skill development through deliberately designed content activity opportunities allowed for individual learners to continue to grow and develop. The PDSA cycle also allowed for teacher reflect and growth regarding classroom environment and instructional patterns. The process shed light on the idea that learning as well as teaching connects more with growth than the focus on perfection.

Appendix A Feedback Rubric

Interpersonal Communication

ELIPSS Enhancing Learning by Improving Process Skills in STEM

Interpersonal Communication	Exchanging information and ideas through speaking, listening, responding, and non-verbal behaviors

Category	Ratings		Observable Characteristics
(A) Speaking	Expressed information and ideas to others		Spoke loudly and clearly enough for all team members to hear
			Used a tone when speaking that invited other people to respond
	0 No evidence; 1 Ineffectively; 2; 3 Adequately; 4; 5 Effectively		Language/expressions were suitable for the listeners and environment
			Duration of speaking was effective for listener or communication
	Suggestions for Improvement: a) Speak audibly and clearly to your team members so everyone can hear you. b) Use a tone of voice that is friendly and inviting. c) Carefully choose your words to align with the level of the material, using phrases and sentences that are comprehensible. d) Choose language that doesn't make others uncomfortable; don't make the setting uninviting. e) Speak for a length of time that allows frequent back and forth conversation.		

Category	Ratings		Observable Characteristics
(B) Listening	Paid attention to the speaker as information and ideas were communicated		Patiently listened without interrupting the speaker
			Turned their attention to the speaker when they were speaking.
	0 No evidence; 1 Rarely; 2; 3 Sometimes; 4; 5 Consistently		Referenced others' ideas to indicate listening and understanding
			Other:
	Suggestions for Improvement: a) Allow team members to finish their thoughts. b) Turn to face the team member that is speaking and make eye contact. c) Indicate if you can't hear someone's spoken words. d) Restate or write down what the previous speaker said to indicate that you were listening and understood their idea.		

Figure 8. Interpersonal Communication[8]

[8] Obtained and utilized from my private and approved ELIPSS Rubrics account.

Appendix B Post Process Skill Data Source – Post Learning Survey for Students

POST LEARNING SURVEY FOR STUDENTS

I. MATCH THE FOLLOWING FORMS OF COMMUNICATION WITH THEIR EXPLANATION.

CATEGORY	EXPLANATION
A. SPEAKING B. LISTENING C. RESPONDING D. NON-VERBAL	I. REPLIES OR REACTED TO THE COMMUNICATED INFORMATION OR IDEAS II. PAYS ATTENTION TO THE SPEAKER AS INFORMATION AND IDEAS WERE COMMUNICATED III. USES PRODUCTIVE BODY LANGUAGE WHILE SPEAKING, LISTENING, AND RESPONDING TO PROMOTE COMMUNICATION IV. EXPRESSED INFORMATION AND IDEAS TO OTHERS

2. RANKING
   A. NOT AT ALL, A LITTLE, A MODERATE AMOUNT, A LOT, A GREAT DEAL
      I. I UNDERSTAND WHAT INTERPERSONAL COMMUNICATION IS.
      II. I WAS COMFORTABLE WORKING IN A GROUP DURING ACTIVITIES.
      III. THE INTERACTIVE ACTIVITIES IN HIGH SCHOOL HELP ME TO DEVELOP CONTENT KNOWLEDGE.
      IV. THE INTERACTIVE ACTIVITIES IN HIGH SCHOOL HELP ME PRACTICE INTERPERSONAL COMMUNICATION.

3. DESCRIBE & EXPLAIN
   A. DESCRIBE THE ACTIVITIES IN HIGH SCHOOL THAT HELP YOU LEARN THE CONTENT MATERIAL.
   B. DESCRIBE HOW ACTIVITIES IN SCHOOL HELP YOU LEARN AND PRACTICE INTERPERSONAL COMMUNICATION.

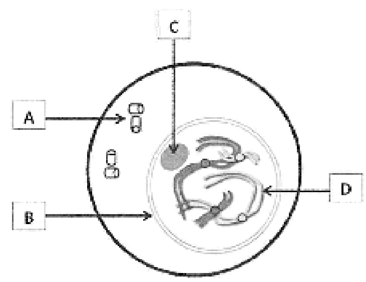
Figure 9. Post Learning Survey

Appendix C Pre/Post Content Data Source

Cell Division Unit Assessment

Complete the questions.

* Required



What is the name of structure A?

If the image does not load, refer to the Quiz folder in Teams and use Quiz Graphic #1. *
(1 Point)

- ◯ Chromosomes
- ◯ Nucleolus
- ◯ Centrioles
- ◯ Nucleus/Nuclear Membrane

/30/2021

Figure 10. Pre/Post Content Data Source: Cell Division Unit Assessment[9]

[9] Adapted from Amy Brown Science Resources and Greensburg Salem Curriculum Resources

Appendix D Reflective Journal Prompt

REFLECTIVE TEACHER JOURNAL

1. WHAT DID I NOTICE ABOUT THE STUDENTS TODAY?
2. WHAT WENT WELL TODAY?
3. WHAT NEEDS IMPROVED FOR THE NEXT TIME?

Figure 11. Reflective Journal Prompt

Appendix E Coding Tool

Code	Code Abbreviation	Brief Definition	Example
Content	CON	Explores the content related experience	"The cell cycle includes 3 phases: interphase, nuclear division, and cell division."
Skill	SKI	Explores the skill related experience	"We need to be sure to record our answers with accurate details so we can communicate them to the whole group."
Process	PRO	Describes the strategies and procedures	"We are struggling to stay within our POGIL roles."
Emotion	EMO	Explores the emotion related experience	"We are frustrated with the key concept."

Figure 12. Coding Tool[10]

[10] Adapted from Plack, M. et al, 2005

Appendix F POGIL Training Presentation for Learners

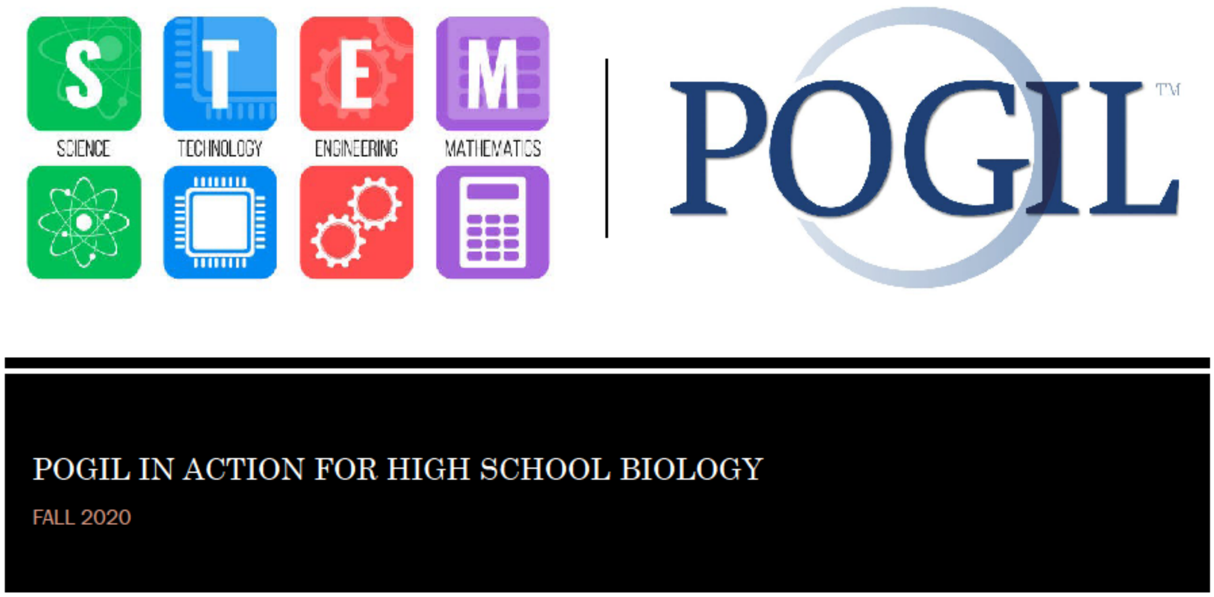


Figure 13. Training Presentation[11]

[11] Created using Simonson, 2019.

Appendix G POGIL Activity on Cell Cycle

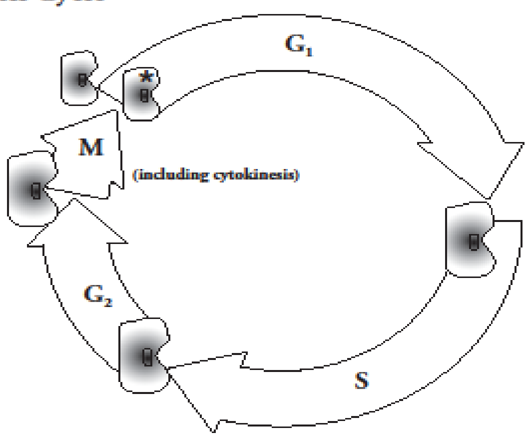
The Cell Cycle

What controls the life and development of a cell?

Why?

An old piece of poetry says "to everything there is a season… a time to be born, a time to die." For cells, the line might say "a time to divide and a time to grow." In multicellular organisms, different types of cells have different roles and need to complete specific tasks. For example, a cell that isn't large enough is not useful for storing nutrients for later, but a cell that is too large will not be useful for transportation through a tiny capillary. In this activity, you will learn about the seasons of a cell's life, and in turn better understand how organisms function.

Model 1 – The Cell Cycle



1. How many phases are in the cell cycle as shown in the diagram in Model 1?
2. Starting at the starred cell, what is the order of the stages of a cell's life?
3. During which phase does the size of the cell increase?
4. During which phase does the number of cells increase?

The Cell Cycle 1

Figure 14. POGIL Activity on Cell Cycle[12]

[12] Obtained and utilized from Trout, 2012

Appendix H POGIL Activity on Mitosis and Meiosis

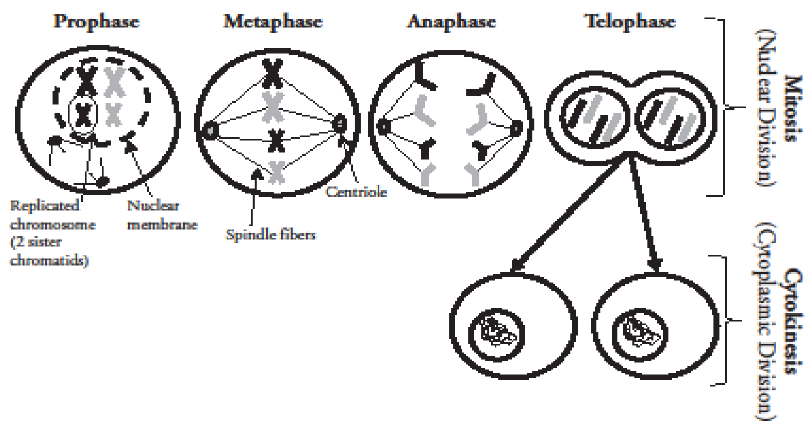
Mitosis

How do living things grow and repair themselves?

Why?

Living things must grow and develop. At times they suffer injuries or damage, or cells simply wear out. New cells must be formed for the organism to survive. What process must occur to make a new, properly-functioning cell?

Model 1 – Mitosis as Part of the Cell Cycle

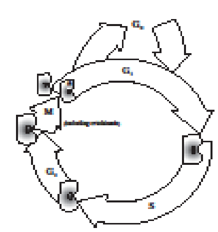


1. Refer to Model 1. List the four phases in the mitosis process.

2. Where is mitosis in the cell cycle? Before ________________ and after ________________.
3. What three phases of the cell cycle are considered **interphase**?

4. Refer to the cell cycle shown.
   a. How many cells are present at the beginning of mitosis?

   b. How many cells are present at the end of mitosis?



Mitosis 1

Figure 15. POGIL Activity on Mitosis[13]

[13] Obtained and utilized from Trout, 2012.

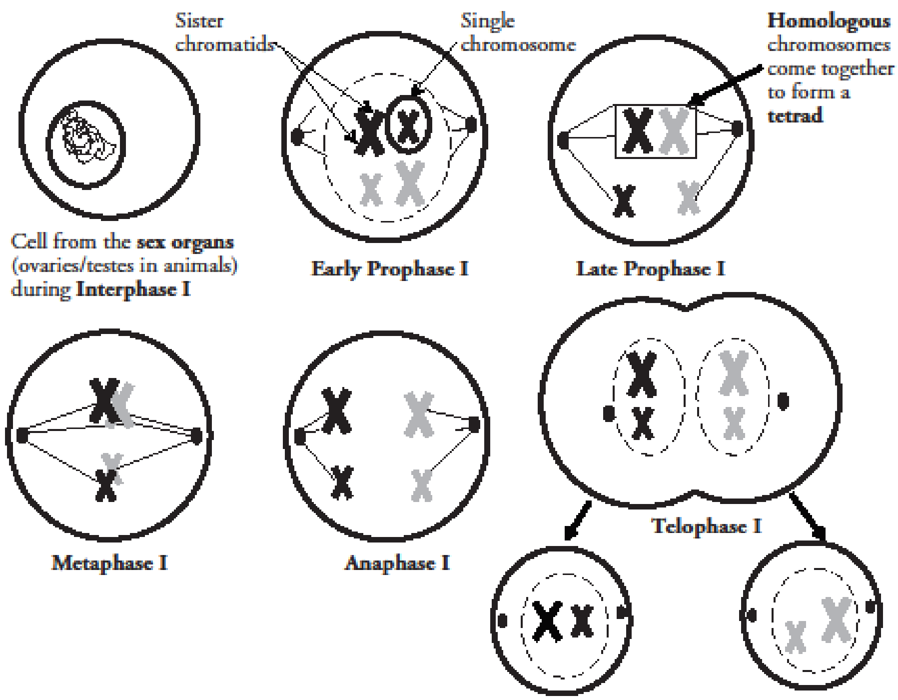
Meiosis

How does sexual reproduction lead to genetic variation?

Why?

Cells reproduce through mitosis to make exact copies of the original cell. This is done for growth and repair. Sexually-reproducing organisms have a second form of cell division that produces reproductive cells with half the number of chromosomes. This process is called **meiosis**, and without it, humans, oak trees, beetles, and all other sexually-reproducing organisms would be vastly different than they are today.

Model 1 – Meiosis I



1. According to Model 1, in what type of organs are the cells that enter meiosis I found?
2. Considering what you already know about mitosis in cells, what event must take place during interphase before a cell proceeds to division?

Meiosis 1

Figure 16. POGIL Activity on Meiosis[14]

[14] Obtained and utilized from Trout, 2012

Appendix I POGIL Role Description Cards

MANAGER or FACILITATOR

- Make sure team starts quickly and remains focused during the activity.
    - Assign tasks for collecting and distributing materials as needed.
    - Assign roles like calculator or significant figure checker.
    - "I think we have everything, are we ready to begin?"
- Takes care of time management.
    - Keep an eye on the clock.
    - Keep team moving forward and communicate about discussion deadlines.
    - "I think we need to focus on ________ so we complete this section on time."
    - "We have ______ minutes before we need to discuss this. Let's get this done."
- Make sure all voices in the team are heard.
    - Address team members by name and ensure that everyone contributes.
    - Assign different members to read sections of activity on a rotating basis.
    - "(Name), what do you think about . . . .?"
    - "I would like to hear what you think, (name)."

MANAGER or FACILITATOR

- Make sure team starts quickly and remains focused during the activity.
    - Assign tasks for collecting and distributing materials as needed.
    - Assign roles like calculator or significant figure checker.
    - "I think we have everything, are we ready to begin?"
- Takes care of time management.
    - Keep an eye on the clock.
    - Keep team moving forward and communicate about discussion deadlines.
    - "I think we need to focus on ________ so we complete this section on time."
    - "We have ______ minutes before we need to discuss this. Let's get this done."
- Make sure all voices in the team are heard.
    - Address team members by name and ensure that everyone contributes.
    - Assign different members to read sections of activity on a rotating basis.
    - "(Name), what do you think about . . . .?"
    - "I would like to hear what you think, (name)."

Figure 17. Role Description Cards - Manager or Facilitator[15]

[15] Obtained and utilized from Kussmaul, 2017

Appendix J POGIL Process Skills Description Card

PROCESS SKILL	Operational Definition
ORAL & WRITTEN COMMUNICATION	Oral Communication: Exchanging information and understanding through speaking, listening, and non-verbal behaviors. Written Communication: Conveying information and understanding to an intended audience through written materials (paper, electronic, etc.)
TEAMWORK	Interacting with others and building on each other's individual strengths and skills, working toward a common goal.
PROBLEM SOLVING	Identifying, planning, and executing a strategy that goes beyond routine action to find a solution to a situation or question.
CRITICAL THINKING	Analyzing, evaluating, or synthesizing relevant information to forr an argument or reach a conclusion supported with evidence.
MANAGEMENT	Planning, organizing, directing and coordinating one's own and others' efforts to accomplish a goal.
INFORMATION PROCESSING	Evaluating, interpreting, manipulating, or transforming information
ASSESSMENT (Self assessment and Metacognition)	Self and Peer Assessment: Gathering information and reflecting on an experience to improve subsequent learning and performance. Metacognition: Thinking/reflecting about one's thinking and how one learns, and being aware of one's knowledge.

Figure 18. POGIL Process Skills Description Card[16]

[16] Adapted from Simonson, 2019

Appendix K Group Summaries

Table 15. Summary of Groups for Block A – Fall 2020 – Regular Biology

Group	Learner Assignment	Descriptive Information	Assigned Roles
Red	A9	RE	M
	A10	RE	P
	A11	RE	RC
	A12	RE	RF
Blue	A13	RE	M
	A14	RE	RF
	A15	IEP	RC
	A16	IEP	P
Orange	A17	RE	M
	A18	RE	RF
	A19	IEP	RC
	A20	IEP	P
Yellow	A21	RE	M
	A22	RE	RF
	A23	RE	RC
	A24	RE	P
N/E	A1	RE	None
	A2	RE	None
	A3	IEP	None
	A4	IEP	None
	A5	RE	None
	A6	IEP	None
	A7	IEP	None
	A8	IEP	None

Table 16. Summary of Groups for Block B – Fall 2020 – Regular Biology

Group	Learner Assignment	Descriptive Information	Assigned Roles
Red	B1	RE	RF
	B2	IEP	P
	B4	IEP	RC
	B5	RE	M
Blue	B6	IEP	RF
	B7	RE	M
	B8	IEP	RC
	B9	RE	P
Orange	B10	RE	RC
	B11	RE	P
	B12	RE	M
	B13	RE	RF
Yellow	B14	RE	M
	B15	RE	RF
	B16	RE	P
	B17	RE	RC
N/E	B3	IEP	None

Table 17. Summary of Groups for Block C – Fall 2020 – Regular Biology

Group	Learner Assignment	Descriptive Information	Roles
Red	C5	IEP	P
	C6	RE	RC
	C7	RE	M
	C8	IEP	RF
Blue	C9	RE	P
	C10	RE	RC
	C11	RE	M
	C12	IEP	RF
Orange	C13	RE	P
	C14	IEP	RC
	C15	RE	M
	C16	RE	RF
Yellow	C17	RE	RC
	C18	RE	M
	C19	RE	P
	C20	RE	RF
Green	C21	RE	RC
	C22	RE	M
	C23	RE	RF
	C24	GIEP/IEP	P
Violet	C25	RE	RF
	C26	IEP	RC
	C27	RE	M/P
N/E	C1	IEP	None
	C2	IEP	None
	C3	IEP	None
	C4	IEP	None

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