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# Improving Student Success in Introductory Chemistry using Early Alert and Intervention

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# Improving Student Success in Introductory Chemistry using Early Alert and Intervention

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## Abstract

Introductory Chemistry is a foundation course that provides students with the basic knowledge and skills to enable them to be successful in the subsequent General Chemistry courses. Despite being an introductory course, it is still challenging for many students, making it ideal for the implementation of various pedagogical initiatives. One such initiative is an Early alert and intervention (EAI) program. Early alert and intervention programs can be described as communication systems which are put in place to help with the timely identification and intervention of students who display attrition risk factors. Data has shown that identifying at risk students early in courses such as Introductory Chemistry and intervening accordingly makes positive impacts on student success. In the fall 2016 semester, pass rates in Introductory Chemistry at one of Miami Dade College's (MDC) campuses saw a sharp decline from that of the collegewide average. An early alert and intervention program was implemented to reverse this decline. This initiative involved the use of a mathematics diagnostic assessment at the beginning of the semester to identify students at risk of failing the course, thus providing the necessary interventions early in the semester. More frequent assessments were also administered throughout the semester to consistently monitor students' progress and provide interventions where necessary. This initiative was conducted over a two-year period and resulted in more than a twenty-percentage point increase in student pass rates for Introductory Chemistry.

## Introduction

Student success (retention and progression) is always a main priority for institutions of higher education and much research has been conducted to improve on these metrics. One of the missions of institutions of higher education is to prepare students to be productive members of society. When a student is admitted into an institution, there is a level of commitment on the part of the institution to support the success of the student for the duration of their degree program (Krumrei-Mancuso et al., 2013). Student success is dependent on many variables, some of which are non-academic while others are academic in nature. Some of these variables that are believed to impact student success include; academic potential, normative congruence, intellectual development, grade performance and friendship support (Cele, 2021). It is believed that student success challenges are mainly due to the performance

of first year students as the transition from high school to college requires a keen balance of social, emotional, and academic variables (Cele, 2021). If institutions of higher education are to overcome these attrition risks, programs need to be developed, implemented, and institutionalized that provide first year students the relevant support needed for success.

Many federal programs have invested heavily in post-secondary education making higher education more accessible in the United States. The most significant of which in terms of impact, dates to 1862 with the passage of the Morrill Land-Grant Act which created 76 public institutions being implemented across the country providing educational access to millions of students (Harris, 2022). With educational access no longer restricted to the most successful or affluent, the need for additional student support has now come to light. Miami Dade College (MDC) in Miami Florida, for example is among the largest institutions in the United States by undergraduate enrollment with over 100,000 students enrolled. As majority of these students are Pell Grant eligible, their success outcomes require more intentional support than those of traditional college students. MDC also enrolls more Hispanic undergraduate students than any other college or university (>70%) and it has the third largest black non-Hispanic undergraduate enrollment in the country at 15%. At MDC, more than half of the students are the first in their families to attend college (first generation), 78% of MDC students work while attending college (22% work full time) and 58% are low income (Pell Grant Eligible) with 49% being below the federal poverty level for their household size (Miami Dade College, n.d.).

While earning a college degree is challenging, it is even more so for students who are first generation and Pell eligible. This is a result of the lack of knowledge about higher education from family to be able to support students on their college journey and the lack of financial resources. The lack of financial resources prohibits additional private tutoring or results in additional time being devoted to work versus studying course materials (Nomi, 2004). To combat these non-academic challenges, MDC has instituted numerous programs enabling students to overcome these hurdles. Students are offered financial aid in a variety of forms including grants, scholarships, work-study, and loans. There are also other resources such as a “Single Stop” program that connects students and immediate family members to public benefits and local resources to which they would not otherwise be aware.

Despite this non-academic support from the College, the academic challenges faced by students remain, which fall in the purview of faculty. Depending on the area of study, faculty have implemented various pedagogical strategies to assist students with overcoming barriers that affect learning. General Chemistry for example is a high impact gateway course. Gateway courses can be defined as the first credit-bearing college-level course required to enter in a program of study (Kwak, 2021). General Chemistry is a high impact course because of the high enrollment numbers and a gateway course because it serves as a requirement for most Science, Technology, Engineering and Mathematics (STEM) students. Student retention in STEM courses is an ongoing problem in the United States as a large percentage of students who enroll for a STEM degree either drop out of the institution or change their major by the second year of college if they are not successful in their courses (Gupta & Hartwell, 2019). This is especially true for women and underrepresented minorities (Harris et al., 2020).

General Chemistry is one of the STEM courses that is a barrier to student success (Stone et al., 2018). This is

evident as observed by the General Chemistry national average pass rates only ranging from 50 to 60 percent within the United States (Goodman, 2017). As this course is a barrier to the retention and progression of STEM students, numerous pedagogical initiatives have been utilized nationwide to improve on student success in this course. Some successful initiatives include peer-led team learning, flipped classrooms and other forms of active learning. Peer-led team learning employs previous successful undergraduate students to serve as peer leaders who lead sessions of structured group work (Mitchell et al., 2012, Smith et al., 2014). In a flipped classroom, the traditional lecture is replaced with more active engagement such as iClicker style questions or workshops allowing students to complete most of the instruction outside of the class through a series of short videos, podcasts, or homework assignments (Goodman, 2017). Other instructors have implemented formative assessments in addition to the traditionally used summative assessments. Many chemistry courses utilize summative assessments which is a cumulative assessment implemented at the end of the course of study. Unlike summative assessments, formative assessments evaluate the students' performance throughout the course. Using formative assessments, instructors can interpret students' results, share the results with the students thus allowing them to understand their strengths and weaknesses and provide them an opportunity to reflect on how to improve (Fischer, 2020). Feedback is an important factor that distinguishes formative assessment from summative assessment.

The chosen pedagogical initiative is often dependent on the student population. At MDC, one of the initiatives employed to ensure that students are adequately prepared for General Chemistry was the institutionalization of a placement test. Students' performance on this test, allows them to go directly to the first semester of General Chemistry or to be placed in an Introductory Chemistry course. In recent years, most students have been forgoing the placement test and going directly to Introductory Chemistry resulting in this course now being the high impact gateway course for STEM students at the College. Studies have shown that student retention and persistence is dependent on their success in gateway courses. These courses, however, can act as barriers to student success especially for low-income, first generation, minority, and female students (Kwak, 2021). Gateway courses are important as they provide foundational knowledge that students will need later in their academic careers. Depending on students' intended major, gateway courses will vary.

This article will focus on the challenges faced in an Introductory Chemistry course at one of MDC's campuses and the early alert and intervention initiatives implemented to overcome these challenges allowing for improved student retention and persistence. Early alert and intervention programs are communication systems which are put in place to help with the timely identification and intervention of students who display attrition risk factors (Hanover Research, 2014). Early alert programs are comprised of at least two key components; alerts and intervention (Hanover Research, 2014). The "alerts" are red flags that indicate a problem that needs to be addressed. These red flags usually indicate issues associated with frequent absences, failing grades, behavioral issues amongst other factors. Based on the issue, the next step of the program, the intervention, can then be implemented.

There have been many studies documenting the importance of identifying at risk students and identifying them early enough to make a difference. As a result, ninety three percent of higher education institutions have reported having some form of early alert and intervention programs (Lynch-Holmes et al.) This increased use of early alert

programs can be attributed to factors such as improvements in information technology, the changing demographics of college students and the increased demand for higher eductaion (Marcal, 2019). These programs are often implemented at the institutional level to improve retention and graduation rates (Hanover Research, 2014). Successful early alert programs require the following components; identifying a target population, building an early alert and intervention team, identifying the indicators that will be used to trigger an alert, intervening, measuring, and learning from the impact of these programs. For this study, the early alert and intervention program with its key components was implemented at the course level.

## Method

### Target Population

Evidence has suggested that early alert programs are most effective when they are designed for specific student populations with a common target population being college freshmen. When a sharp decline in Introductory Chemistry pass rates was observed in the fall of 2016, an early alert and intervention pilot study was conducted in the spring of 2017 to address these declines. This course was an ideal target population as it is comprised predominantly of freshmen students and Introductory Chemistry also serves as a gateway STEM course at MDC.

Two sections of this course taught by the same professor were identified for the early alert and intervention pilot study; one section served as the control group while the other section served as the test group. The traditionally taught class will be referred to as the control group while the early alert and intervention (EAI) class will be referred to as the test group. Each section had an enrollment capacity of 45 students. The control group was taught in a traditional manner consisting of 50-minute lectures three times per week with three assessments administered at five-week intervals and a cumulative assessment at the end of the semester. The test group had similar instructional protocols and assessments as the control group, but modifications were made in the form of additional low stakes assessments to identify weaknesses at the beginning and throughout the course of the semester that could be remediated in a timely manner.

The low stakes assessments included a ten-question mathematics diagnostic test administered during the first week of class. The mathematics diagnostic test was administered at the campus' testing department. Making the assessment computer based allowed for instant feedback while also maintaining the integrity of the assessment. The instant feedback was crucial for the mathematics diagnostic test as this allowed the students who needed mathematics remediation to be identified, contacted, and assisted early in the semester. End of chapter quizzes were also administered approximately every ten days to gauge students' understanding of the material. Performance on these frequent assessments highlighted the shortcomings that students had throughout the course, providing opportunities to remediate these shortcomings in a timely manner through various means of interventions.

### Early Alert and Intervention Team

A study conducted by the Garner Institute (Hanover Research, 2014) states that even though academic advisors

and faculty are often most involved in early alert programs, it is common for there to be additional resource personnel in the form of peer staff such as tutors and mentors. To assist the professor with the early alert and intervention pilot study, the test section of the course was assigned a tutor. The assigned tutor was a peer academic leader (PAL).

The PAL was a current MDC STEM student who had excelled in math and chemistry courses. The PAL received an intensive two-day training prior to taking on tutoring assignments as well as additional monthly 30-minute web-based trainings to support academic achievement. An integral part of the training dealt with the Family Educational Rights and Privacy Act (FERPA) to ensure that tutors were knowledgeable about the privacy of students' education records. Training and compensation for the PAL was provided by a Title V STEM grant. The faculty member met weekly with the PAL to provide instructional progress ensuring that the PAL was adequately prepared for tutoring sessions. The PAL also provided the instructor with an update on the tutoring sessions. These updates from the tutor provided the instructor with crucial feedback on concepts that students were struggling with but were not willing to voice in the classroom setting. This has been one of the strengths of this program; coupling the early alert process with peer tutoring interventions.

**Identifying Indicators used to Trigger Alerts and Interventions**

During the first week of class, students scoring 60% or less on the mathematics diagnostic test or students who did not take the mathematics diagnostic test were identified as at risk of failing the course. The diagnostic test was administered at the campus' testing center using the College's learning management system, Blackboard. This provided the faculty member with immediate results allowing for the identification of students who needed math remediation. At risk students were identified by the faculty member and contacted to schedule an appointment with the PAL during week two of the semester to review the diagnostic test.

Early alert programs typically use various forms of monitoring; within the first few weeks of class, at the midterm or ongoing throughout the semester. This study utilized an ongoing approach. In addition to the mathematics diagnostic test, more frequent assessments in the form of end of chapter quizzes were administered throughout the course of the semester. These quizzes were administered approximately every ten days. Students scoring 60% or less on these end of chapter quizzes were identified as at risk and the necessary interventions provided. These assessments allowed the faculty member to interpret students' performance, provide feedback and recommend interventions. Feedback was in the form of printed personalized progress reports, provided after each assessment. The progress reports notified students of their deficiencies and the need to meet with the PAL that was assigned to the class.

In addition to the printed progress reports, students who were at risk of failing the course were also notified via short messaging service (SMS) - text messages. At the beginning of the semester, students were asked to opt into "Remind" which is a free text messaging mobile application (app) that allows teachers and students to communicate quickly and efficiently. The PAL was also able to communicate directly with the students using this app to make one-on-one tutoring appointments. Using this app proved to be more beneficial than email in

contacting students. Use of this app also ensured that students, who were at risk of failing the class, were never openly identified to their peers. The tutoring sessions provided by the PAL gave students opportunities to work on areas of weaknesses.

## Results

### Pilot Study Comparing Test Group and Control Group

The implementation of the early alert and intervention pilot resulted in student pass rates in the test group increasing more than twenty percentage points (see Figure 1). The pilot study showed that the test group had a 60% pass rate and 88% retention rate compared to the control group which had a 31% pass rate and 73% retention rate. This increase in pass rates was accomplished by modifying the way in which the course was taught. In addition to tests given at five-week intervals and the cumulative final exam, more frequent assessments in the form of quizzes were administered. The more frequent quizzes provided students additional opportunities to earn points and since these quizzes covered individual chapters, it allowed for ease of learning the material. Feedback for these assessments were provided by the following class period. This prompt feedback allowed for identification of areas of weakness providing the instructor an opportunity to review concepts in a timely manner. As class meeting times are limited, students who earned 60% or lower on these assessments were asked to meet with the tutor for additional review and practice.

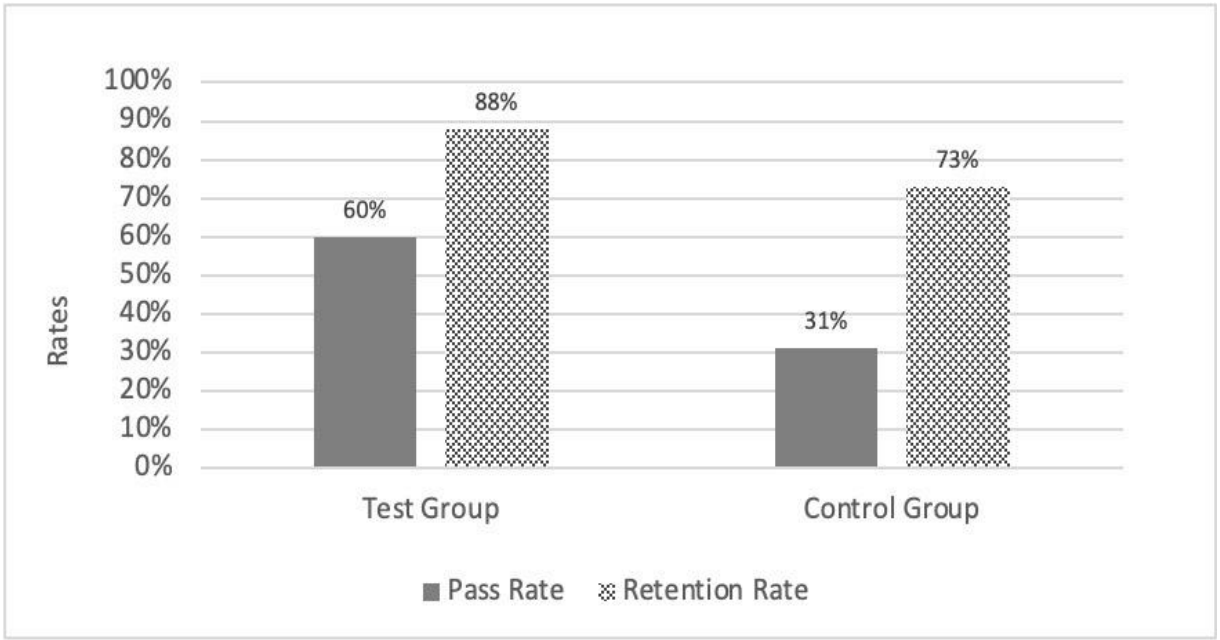


Figure 1. Pass Rates and Retention Rates for Pilot Study

Use of the frequent individual chapter assessments allowed students to be better prepared for the tests that covered multiple chapters. The more frequent assessments were administered approximately every ten days requiring students to study consistently rather than waiting for the night before a test to begin studying as is the typical behavior of first year students. A review of the grade distribution also shows that the test group had more students earning B's and C's and fewer F's and W's when compared to the control group (see Figure 2).

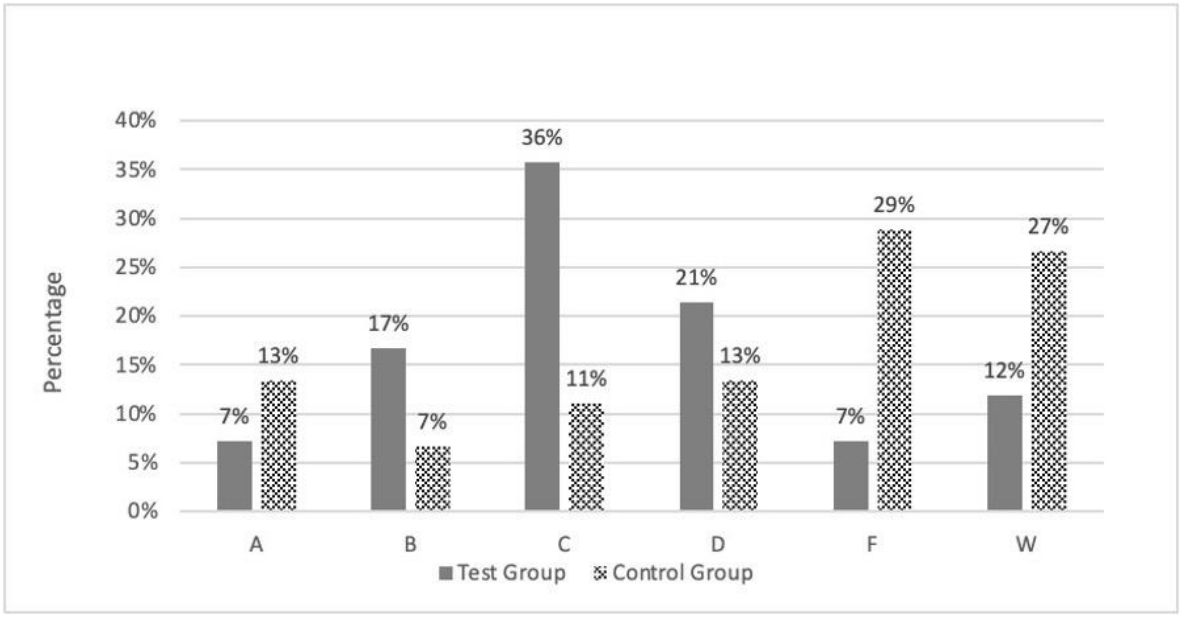


Figure 2. Grade Distribution for Pilot Study

**Two-year Study Implementing EAI**

The preliminary results obtained from the pilot study resulted in a more long-term study which was conducted to determine if the results could be replicated. The long-term study began in the fall of 2017 and continued through to the fall of 2019. Average pass rates range from 53% to 55% (see Figure 3) which is more than a twenty-percentage point increase when compared to the control group from the spring 2017 pilot study and to classes prior to the pilot study (the pass rates of those classes are not shared in this article but are similar to pass rates of the control group in the pilot study).

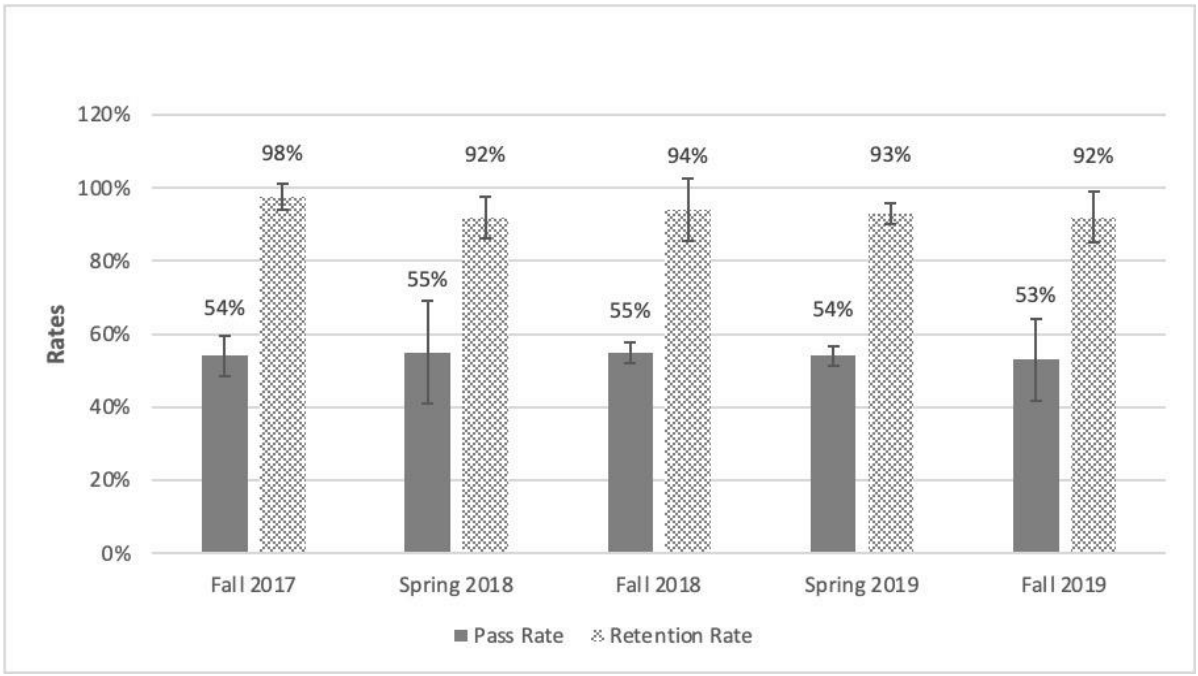


Figure 3. Average Pass Rates and Retention Rates over Two-years

The grade distribution for the two-year study period (see Figure 4) showed the same pattern that was observed in the pilot study; students earned more B's and C's and fewer F's and W's.

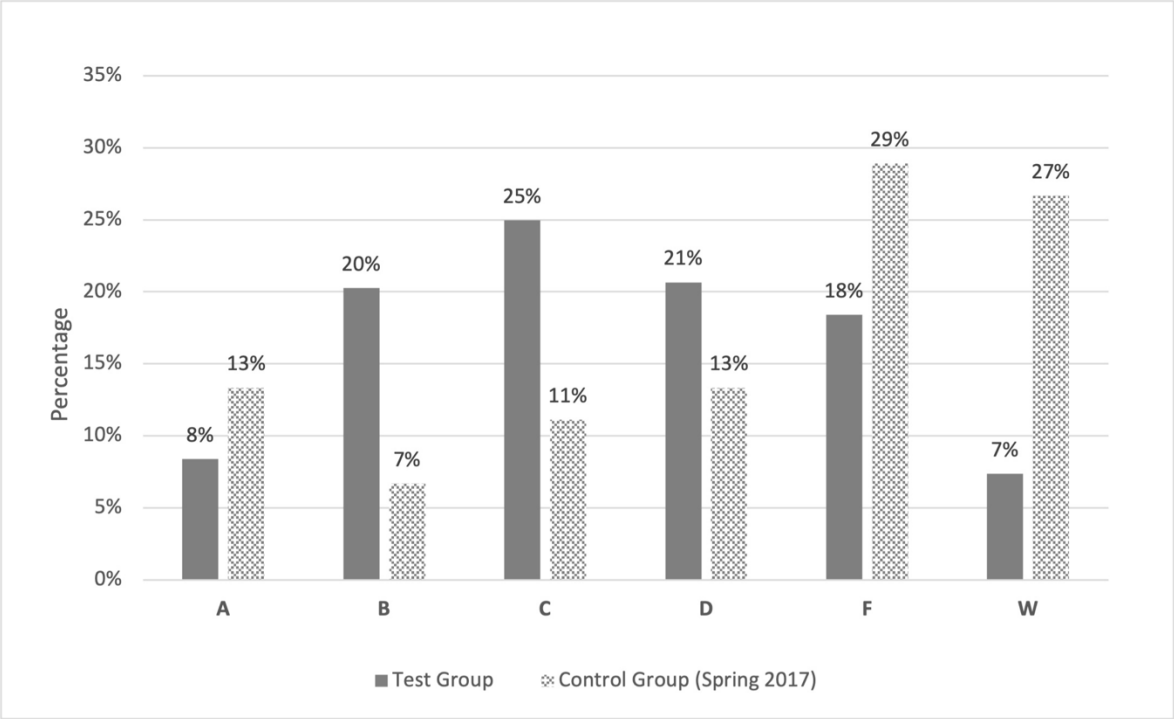


Figure 4. Grade Distribution over Two Years

## Discussion

Early alert programs have been an integral part of student retention and success especially at community colleges that have high attrition rates (Dwyer et al., 2018). One way to decrease the attrition risk is to increase academic success. One of the first steps in increasing academic success is to identify at risk students early in the semester and intervene accordingly (Marbouti et al., 2016). Early alert programs may be designed differently across institutions, but they all have a common goal; to identify at risk students and to provide the necessary intervention in a timely manner to improve retention and success rates. Many institutions have been utilizing academic technology systems to support early alert programs. These systems usually allow faculty to flag students who are at risk of failing a course due to a variety of reasons which may include but not limited to numerous absences, poor performance on assessments or lack of engagement in class. Academic advisors receive this data, and the at-risk students will then receive an early alert communication. This early alert communication may be an email or a phone call from an academic advisor who refers the at-risk student to campus support services such as tutoring or mentoring services. Students, however, are not always responsive to emails especially if it is a generic email that is received from an unknown individual. Sometimes, faculty may flag a large number of at-risk students, overwhelming advisors thus diminishing the advisors' ability to resolve all the cases in a timely manner. Faculty eventually receive a case closed notification, but this does not always inform the faculty member of the actions that were taken to assist the student (Marcal, 2019). These are some of the downfalls of early alert programs but there are fixes to these issues. A study which examined how an early alert program promoted student visits to

tutoring centers found evidence which suggests that an early alert system that is focused on personalized feedback positively correlates with the help-seeking behavior of at-risk students in gateway courses (Cai et al., 2014).

The early alert program allowing for personalized feedback to the students that was utilized in this study did not involve the use of a typical institutional implemented academic technology system nor the assistance of advisors at that institution. It was instead conducted at the course level rather than at the institution level. This allowed for personalized feedback to the students in the course because of the consistent and direct communication between the professor, students, and tutors. This personalized feedback to the students was a low cost yet effective approach that may be implemented broadly at any 2- or 4-year institution. Empirical data has shown that identifying at risk students early in a gateway course such as Introductory Chemistry and intervening accordingly could make a big impact on student success. However, implementing early alerts in Introductory Chemistry required modifications to the design of the course. The course was taught in a very traditional manner; three assessments administered at five-week intervals and a cumulative assessment at the end of the semester. However, based on students' performance, this was not the best approach for student success, as a result the course was modified to include an early alert program that was implemented at the course level. This early alert program included more frequent assessments which allowed students to be consistently monitored throughout the semester and provided personalized feedback in a timely manner. Based on the implemented changes and the resulting metrics, the authors attribute the more than 20%-point increase in pass rates observed over the two years to the different strategies used.

Having a strong foundation in mathematics has been reported to be crucial to the success of students in chemistry as many chemistry concepts are dependent on mathematics (Stone et al., 2018). A large number of students taking Introductory Chemistry, struggle with mathematical concepts and so a mandatory mathematics diagnostic test was a part of the course modification. The mathematics diagnostic test was administered during the first week of class allowing mathematics deficiencies to be identified. Being able to identify the mathematical deficiencies early in the semester, means that the students who were at risk of failing because of these deficiencies could be provided with the necessary resources in a timely manner. To provide instant feedback, the mathematics diagnostic test was computer based and administered through the College's testing center. The instant feedback was crucial for the mathematics diagnostic test which allowed the students who needed mathematics remediation to be identified, contacted, and assisted within the first two weeks of classes.

Most students who take Introductory Chemistry are usually in their first year of college and one of the shortcomings that have been identified with this group of students is that they do not work consistently throughout the semester, which usually proves detrimental to their success. In modifying the course, more frequent assessments were implemented in the form of end of chapter quizzes. End of chapter quizzes were administered approximately every ten days. The frequent assessments were beneficial in several ways; students were learning the material in smaller chunks and the frequent assessments resulted in them working consistently throughout the semester rather than studying immediately before a test or an exam. Prior to taking a test or an exam, students were already assessed on these topics and if they did not perform well, remediation was performed making them better equipped for the high stakes tests and exam. The frequent assessments also provided additional

opportunities for students to earn points. Previous studies have noted that providing students frequent feedback have adjusted students' behavior promoting student success in the classroom (Tinto, 2012). The benefit of these frequent assessments was demonstrated by the grade distributions seen in Figure 2 and 4 where students earned more B's and C's and a fewer F's and W's.

Performance on these frequent assessments highlighted the weaknesses that students had and provided opportunities for remediation in a timely manner through various means of interventions. Interventions were in the form of personalized progress reports, provided after each assessment, which notified students of their deficiencies and the need to meet with a tutor that was assigned to the class. These personalized progress reports were distributed during class by the professor. In addition to the personalized progress reports, students who were at risk of failing the course were also notified via text messages to meet with a tutor. Students were very responsive to the text messages as they could schedule individual tutoring sessions via this medium. Having tutors with whom the students were familiar gave them a level of comfort that resulted in them readily attending tutoring sessions. The pilot study showed that students who attended tutoring for more than 10 hours over a three-week period earned an average grade of B. The direct communication from the professor and follow up from the assigned tutors seemed to be more effective than a generic email that is oftentimes sent via an academic technology system when early alert programs are administered at the institution level. The early alert program used in this study resulted in significant gains in pass rates and the authors believe that this was a result of the various strategies that were utilized particularly the implementation of the program at the course level. Maintaining these close interactions between students and faculty was tedious and time consuming but studies have documented that it is these intense close relationships that enhance student learning and intellectual stimulation (Komarraju et al., 2010).

## Conclusion

In higher education, student success has many definitions. It can be defined as students' persistence to graduation or completion of learning goals. Regardless of how student success is defined, early engagement and purposeful educational activities are paramount. A sharp decline in student pass rates for Introductory Chemistry, a gateway STEM course, at one of MDC's campuses called for an early engagement and purposeful educational intervention. This was in the form of a pilot study for an early alert and intervention (EAI) program. The pilot study showed promising results which led to the implementation of a long-term study of the early alert and intervention program from the fall of 2017 to the fall of 2019. The increases which were observed in the pass rates can be attributed in part to the inclusion of more frequent assessments. Through these frequent assessments, students at risk of failing the course were identified (alerts) and provided with prompt feedback giving them opportunities to reflect on their weaknesses. In addition to the opportunity to reflect on areas of weaknesses, resources (interventions) were provided to assist students in remediating these weaknesses.

As mentioned above, the gains which were attained through this study were not solely a result of the more frequent assessments but also the use of peer tutors for the interventions. Since students share more openly with their peers, the tutors were made aware of topics of weaknesses which may not have been identified through the quizzes.

Through the weekly meetings with the tutors, the professor was made aware of these topics and intervened accordingly usually through review sessions prior to high stakes tests. Communication played a vital role in improving the pass rates of students in this critical course. Multiple channels for communication were crucial as not all students respond to communications in the same manner. Some students only needed the communication provided on their personalized progress report to act on the instructions while other students needed the additional follow up communication via the remind app (text messages) which allowed for one-on-one communication with the tutors. These one-on-one communications allowed students to arrange tutoring times which were most convenient to them. An important lesson learned throughout this process was the tailoring of the messages being communicated to the students. It was important that these communications were written in a way offering help rather than scolding students for not performing. It was observed that tailoring the language in this way made students more receptive to tutoring.

The combination of an early alert and intervention program with peer tutoring provided much needed improvements in pass rates for Introductory Chemistry. Although this increase is commendable, there is still much work to be done to provide even more gains in this course since Introductory Chemistry is currently one of the STEM gateway courses. The more students who are successful in this course, the greater the success and retention rates will be for the STEM students at the College.

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