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**On Collaboration: An Important Skill
for Mathematics Educators for the 21st Century**

Abstract

Mathematics, problem solving, and critical-thinking are key skills to innovation. Not only does the 21st century workforce require mathematics skills for success in everyday life but also for scientific advancement and technological development so as to enhance global competitiveness. Since teaching as an individual process in the 21st century classroom is no longer effective, mathematics educators should embrace practices that foster 21st century skills to their learners. Collaboration is a key skill that not only empowers teachers of mathematics in handling the bigger challenges of the 21st century education but also enables students to succeed in today's world. When we think about collaboration, many different types exist. Most of all major turning points in our history were motivated by a collaborative effort. With any new teacher entering the profession, one needs a mentor to help guide us through the first years of the profession. This is where collaborations start. However, collaborations in education should never stop and should always be on going, as there is always something new to learn. This presentation will outline why collaboration in education is important for both the mathematics educator and student. In addition, the presenters will also outline personal examples of collaborations and provide some ideas on how to obtain and maintain collaborators. This, we believe, can help prepare educators and learners for the challenges in life ahead.

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On Collaboration: An Important Skill for Mathematics Educators for the 21st Century

Peter T. Olszewski and Dickson S. O. Owiti

Abstract. Mathematics, problem solving, and critical-thinking are key skills to innovation. Not only does the 21st century workforce require mathematics skills for success in everyday life but also for scientific advancement and technological development so as to enhance global competitiveness. Since teaching as an individual process in the 21st century classroom is no longer effective, mathematics educators should embrace practices that foster 21st century skills to their learners. Collaboration is a key skill that not only empowers teachers of mathematics in handling the bigger challenges of the 21st century education but also enables students to succeed in today's world. When we think about collaboration, many different types exist. Most of all major turning points in our history were motivated by a collaborative effort. With any new teacher entering the profession, one needs a mentor to help guide us through the first years of the profession. This is where collaborations start. However, collaborations in education should never stop and should always be on going, as there is always something new to learn. This presentation will outline why collaboration in education is important for both the mathematics educator and student. In addition, the presenters will also outline personal examples of collaborations and provide some ideas on how to obtain and maintain collaborators. This, we believe, can help prepare educators and learners for the challenges in life ahead.

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1. Introduction

Collaboration is a process of working together to reach a goal by putting talent and expertise to work. When we think about the word “collaboration,” many different types exist. In the United States, most of the major turning points in our history were motivated by a group of people by a collaborative effort. These events such as the Declaration of Independence in 1776, the civil rights movement, and gay and lesbian rights would not have been possible if not for a select group of people who wanted change. In Kenya, the much enjoyed and celebrated independence would not have been possible if it were not for the collaboration of the famous Kapenguria six and a few more others.

In education, the days of having one teacher in the classroom with thirty or more students being the only primary source of where students learn are non-existent. The 21st century teacher is not simply coming to school, teaching, grading, talking to parents, and going home. The 21st century teacher is being inundated with seminars, conferences, individual education plans, emails from parents, good examination results and new teaching technologies to adapt to the new teaching practices for the millennial generation. Today's student too need to experience the environment they will enter as modern day workers and develop higher order thinking skills such as effective communication, collaboration, and being adept with using technology that they will need in the 21st century workplace. The 21st century skills therefore form an essential component of modern day learning and if properly inculcated into learning can reform it for the better. The educational practices of the traditional classroom are thus no longer effective and teachers must develop new teaching strategies that are radically different if success is to be realised. As Connelly and Clandinin (1994) point out: The horizons of our knowing shift and change as we awaken to new ways of "seeing" our world, to different ways of seeing ourselves in relation to each other and to the world. We begin to retell our stories with new insights, in new ways. *In this paper, we explore four key points:*

1. Why collaboration in education is important
2. The importance of collaboration for the 21st century educator and for the students
3. We will outline our personal examples of collaboration and what they mean to us, and
4. How to obtain and maintain collaborators.

2. Why is Collaboration Important?

Collaboration is the ability to work effectively with others, including those from diverse groups and with opposing points of view to achieve a common goal by solving problems, inventing, creating and producing results (Saxena, 2013). Now more than ever, two or more teachers and or students explicitly agreeing among themselves to meet and accomplish a particular goal or goals is a vital part of education (Clift, Johnson, Holland, & Veal, 1992). With the ever-changing world and the rate at which technology is growing, teachers need to have the latest and most up-to-date teaching practices and best practices at the ready to get students ready for global competitiveness. For Clandinin (1994), collaborative research projects are "attempts at establishing research relationships founded within conversations. Through these conversations, a mutual trust between the individuals is obtained with the openness and willingness to listen to other's point of view. Students need to get latest information and ideas from global perspective. Robinson and Darling-Hammond (1994) have identified 10 characteristics required for achieving successful school-university collaboration:

1. Mutual self-interest and common goals.
2. Mutual trust and respect.
3. Shared decision-making.
4. Clear focus.
5. Manageable agenda.
6. Commitment from top leadership.
7. Fiscal support.
8. Long-term commitment.
9. Dynamic nature.
10. Information sharing and communication.

We believe these are the ingredients to a successful and healthy collaboration in academia no matter the discipline. It is also important to note that collaboration builds strength among the participants. With the diverse knowledge from persons coming together, new ideas are formed from old ideas and practices. As Carse (1986) points out, "Power is never evident until

two or more elements are in opposition.” Collaboration is a means to hearing a diverse body of knowledge and to build upon that knowledge to benefit not only the instructors but also the 21st century student.

3. Why is Collaboration in Education Important?

Collaboration is important because through it we can learn more and better by supporting each other emotionally and committing to cumulative efforts and effects. Studies and research are evident of the fact that better teaching and learning outcomes are achieved when teachers work in collaboration with each other. Working together encourages and contributes toward the achievement of a common goal.

Collaboration promotes further discovery in a research topic, classroom lessons, and provides new avenues of thinking and consideration that may have never been considered before. As similar to networking and meeting people at conferences, collaboration paves the way for ideas to flow among educators and students as well. It widens your circle of people you meet along your educational career and through a collaborative project, other ideas may formulate in terms of research, textbooks, and teaching practices. One can always improve and should always be willing to try new things. With the millennial generation, students are asking the question, “What will I use this for in life?” Simply teaching the pure mathematics engraves in our minds from our schooling years is NOT enough for our students. Students need to acquire 21st century skills for survival. Collaboration for the 21st century professors on how to teach students new skills they need and applications are at an all time high. They have a positive influence on student interest and engagement. Lesson study by Japanese teachers is one such gesture reported to have great impact on teaching and learning.

The importance of collaboration for the 21st century educator and the student According to Saxena (2013), the attitude of professional privacy is most prevalent among teachers of Mathematics. When it comes to their performance in the classroom, most teachers tend to restrict themselves and this hinders their growth, awareness and keeps them restricted to their conventional teaching practices and ideas. It should be realized that professional development and growth hugely depends upon effective teacher collaboration. Formal and informal collaborations help teachers learn a lot from each other and to get the most out of them teachers should seek each other, ask for advices and share how they work, they should spend time, help each other and build relationships. They should observe as many colleagues as possible to see how they teach or learn and seek out the ones they’d like to emulate. They should ask questions regarding student data, instruction, discipline and must be prepared to share their own knowledge. Systemic, critical and creative thinking skills which teachers gain through conversations and collaboration with colleagues should be encouraged so that the work they do with their students. They should bring up topics they want to discuss so that they can get ideas for strategies from each other. They can also analyze outcomes of what their students are doing either content-wise or may be 21st century skills as that gives them a chance to try things out in a collaborative setting before they work on them with their own students. Focus on skills transforms teachers from being mere knowledge givers to facilitators on how the relevant knowledge and skills can be acquired. This will help prepare our students for a future in which they become capable leaders of tomorrow.

4. Our personal example of collaboration what what they mean to us

In 2007, a collaboration between Prof. Dr. Kaisser of University of Hamburg in Germany and Owiti connected Owiti to Prof. Dr. Thomas Janke of the institute of Mathematics in the University of Potsdam in Germany who later invited Owiti to the institute and became a guide

in his PhD research and thesis writing. Besides, Dr. Bennard Bari, the academic director of AIMSSEC in South Africa, through Dr. Rejoyce Gadhi also extended an invite to Owiti in 2014 to take part in research and in service training programme for teachers of Mathematics. Owiti's most enriching collaboration is that with Prof. Olszewski (co presenter) in which apart from writing conference papers like this one and international journal publications, Owiti has benefited by getting access to some of the latest publications and ideas on Mathematics Education. Owiti also have ties with Prof. Jill Adler of Wits which will lead to being more grounded on cutting edge research in Mathematics Education. A journey of miles starts with a few steps.

Our other personal examples of collaboration deal with Prof. Olszewski's first grant on the use of effective study skills using Exam Wrappers. In this grant, the Director for Student Initiatives teamed up with Prof. Olszewski to design question prompts to motivate students to use specific study skills for a Math of Money class. In addition, two of Penn State Behrend's tutors were brought in to share their perspectives on how they study. Prof. Olszewski and Prof. Daniel J. Galiffa established the installation of the 362nd Chapter of Pi Mu Epsilon at Penn State Behrend on October 12, 2012 through a collaborative and shared vision. Both men wanted to promote the mathematics excellence Penn State embodies in the mathematics major and recognize the students for their love of mathematics. Prof. Olszewski has also developed two courses at Behrend, the Mathematics of Money and a Hybrid College Algebra I class. Mathematics of Money was developed through the shared knowledge of several individuals at University part and the hybrid class was developed in conjunction with the nursing department as the class has specific focus for nursing students and with Jessica Resig, Director of the World Campus at Behrend. Lastly, Prof. Olszewski is currently piloting a study on online homework and if it can be used in a mathematics laboratory setting with instructor and tutoring assistance to help students understand concepts more effectively in College Algebra through PreCalculus.

5. How to obtain and keep collaborations

For a beginning teacher, this maybe a hard venture at the start. We offer the following suggestions:

- a. Attend conferences and section NeXT meetings are full with other young faculty and seasoned faculty who are more than willing to pass down their knowledge to you. Always listen to others and ask questions at these meetings. In addition, be willing to travel to conferences like this one. The chances of meeting others in your same field are greater.
- b. Be not afraid to talk to people no matter what their ranks maybe, this includes high school teachers. Sometimes, new faculty can be intimidated by higher ranked faculty but don't be. By asking them questions and advice, you may be more surprised how willing they maybe to offer some good advice. There is also a lot that can be learned about incoming freshmen by collaborating with high school teachers in your area. Take some time to reach out to your local high schools to get the inside perspective to the next incoming class for the fall semester.
- c. Join the MAA or AMS or any Mathematical society. There are always many things one can do to help grow the amount of people you meet for possible common ideas.
- d. Talk to your colleagues at your university as sometimes, one of your best collaborators maybe next door to your office. In short, get out of your office.
- e. Keep conversations going on email, phone, etc. Have clear goals by making sure all people have a passion for the topic of interest, and be willing to change the course of your research and try different things.
- f. Be ready for "no" answers too. Not all collaborations can happen and one must be willing to accept this.

- g. Write down your conversations, as ideas tend to leave the brain quickly when they are verbally talked about quickly.

There can be a lot more other strategies that schools can adopt to invite their teachers to collaborate with one another. Here are some strategies pertaining to real-life practices to help promote teacher collaboration:

- (a) Video tape and discuss lessons: Teacher can videotape themselves while teaching a lesson and share those videos in small focus groups. The group members can watch the lesson and provide the teacher with feedback. This can give teachers time to have constructive conversations about the quality of instruction, teacher assignments, and student work. Consequently, discussions can lead to changes in instruction and student assessments.
- (b) Make the most of interactions in Staffrooms: The staffroom is always the most appropriate place in a school for spontaneous interactions and sharing. Here, teachers find it comfortable to connect with each other, and the conversations they have often get them interested in what is being done in other classes, what teaching practices are being followed and how much progress the students are making. Participate in staffroom interactions to increase popularity of informal observations. This also encourages you to be part of other teacher's classrooms and observe their teaching which is a direct result of becoming interested in the discussions you have in the staffrooms about the teaching strategies. Teachers who are experts in different areas should not shy away from sharing their knowledge because it does not only benefit other teachers but also students.
- (c) Encourage Professional Learning Communities (PLCs): Teachers should form voluntary regional collaborative groups in which they come together regularly to learn about and focus on particular topics. This will help teachers put what they learn into action, and to provide a comfortable environment where teachers are free to take professional risks. The first step in creating an effective learning community is to develop a shared vision, mission, and goal. If all teachers buy in, the collaboration will be meaningful and so provide more effective learning experiences for students. These communities can be developed with the help of a variety of resources such as websites, books, blogs, and videos that provide sample materials and information.
- (d) Collaboration should be regular and scheduled: Experienced teachers should work closely with beginners to help them implement new curriculum and strategies and provide support and feedback. There could be scheduled weekly meetings during the school day in which teachers collaborate, set up observations, and provide feedback to one another. We hope these practices encourage teacher collaboration and you can adopt them in your own schools, colleges or universities to add a significant element to the professional development of and teaching practices by teachers.

Not all collaborations are a win, however, working with each other, we can always learn something new. Collaboration is not easy. Often times, there can be disagreements, arguments, and sometimes, feelings can be hurt. However, if we don't try new things and talk to fellow colleagues, how will we know what else is out there? How we will know if there is a better way to teach a simple concept as adding two unlike fractions? As Olson (1995) points out, "What is problematic to us provides the impetus for future learning as we try to understand ourselves and others, including the students in our case."

6. Conclusions

Many teachers today feel overwhelmed by the wide range of their students' learning needs and levels of preparedness. The educational practices of the traditional classroom are no longer effective and teachers must develop new teaching strategies that are radically different from

those employed in the traditional classrooms. The modern day classroom should be more centered on students and teachers should take the role of facilitators and guides instead of being mere providers of knowledge. They must ensure that they engage their students in learning and provide effective instruction using a variety of instructional methods and following different pedagogical approaches aided with technology. To achieve this they should be active participants in their own learning and must seek out professional development to improve their performance and their students' learning.

Teaching and learning in isolation are very restrictive and hinder progress. Learning in groups enhances the scope of learning and develops critical thinking. Collaborative learning redefines traditional student-teacher relationship in the classroom. Technology plays a big role in developing all of these characteristics for modern classrooms. These classrooms enhance the learning experience and better prepare students for higher education and workforce. We can accomplish more together than even the best of us can accomplish alone. For collaboration to produce results, group members should see each other as having different resources in the form of information, cognitive styles, cultures, decisions, etc., and should also understand that they have come together as equals to do a job. The problems we face today can be better approached through community effort because for complex problems or for a better understanding of any problem, multiple perspectives are required to analyze situations, imagine solutions and develop strategies to achieve them. What's most needed is the commitment that comes from collaborative work in order to follow through on our plans. Embrace the wisdom of crowds.

Collaboration is something that does not necessarily come naturally and working effectively with others is a challenging task in itself. Effectual collaboration requires training and the development of key personal skills. If teachers want their students to work together effectively they should explicitly teach and model collaboration skills. These skills include Active listening, Respect, Manners, Positive Attitude, being focused and Social Awareness. Simply telling students to work together wouldn't result in productive collaboration. Teachers should make students part of activities and projects where they find reasons to collaborate in order to accomplish a common goal. Students should be taught how they can be good and responsible group members through modelling, role playing, discussion, and facilitating. To foster the process of collaboration, teachers should adopt the terminology of teams rather than groups, since teams focus on accountability and commitment, are formed for a purpose and operate through norms and shared expectations. They should incorporate and adapt the high-performance principles common in a working environment to teams in the classroom. This requires time, good coaching skills, a focus on the quality of interaction between students, and a set of team tools, including contracts, rubrics, and exercise. Here are some ways in which collaboration can be taught and learned:

1. Assigning clear responsibilities to every member of the team and making clear what they need to accomplish as a team.
2. Providing illustrations of activities portraying collaborative work and efforts.
3. Assigning a leader who can responsibly take control of the activities of a group.
4. Encouraging self-direction and motivation.
5. Keeping track of the progress of the team and identifying areas of conflicts or their shortcomings as a team.
6. Conducting group and self-evaluations based on the progress.
7. Designing a rubric to measure the process and product.

To be part of the working world in the future, students need to learn to collaborate as a member of a team. Collaboration is one of the most significant skills required in a work environment and every student needs to be prepared for that environment, partly for employment opportunity, but mainly because learning and creating as an individual process is no longer effective. Effective communication is one of the main factors that drives collaboration and leads

to best expressions of innovation, creativity and critical inquiry. Once students get a little used to with working in teams, take responsibility and begin to collaborate well, they get to learn more, can assist and teach each other, develop powerful solutions and altogether enjoy the entire process if working in a team. This can lead to remarkable results. Teachers need to be involved with other teachers and mentors to learn about better teaching. They should come together, take a professional development and collaborate. In order for students to be successful and be able to demonstrate and apply these skills, teachers as adults in the learning system have to be ongoing adult learners and model the same skills in the work that they do professionally and in the classroom with the students. Being able to synthesize and transmit ideas in both written and oral formats is essential in collaboration. For teachers, effective communication and collaboration are the 21st century skills to be really emphasized on. Professional learning communities (PLC) which are effective at breaking the isolation of the individual teacher and help institute a collaborative community of practice should be formed. Focus on collaboration will help all educators to pause and reflect about what they do with the valuable time they have with students. There has been a lot of talk about knowledge economy and global competitiveness. The essence of these includes Creativity and Innovation, Critical Thinking and Problem Solving, Communication and Collaboration. These skills help develop the qualities that the students need to possess in the 21st century for success in college, careers and citizenship. Today's students are moving beyond the basics and embracing the super skills for the 21st century.

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