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STEM Shift Action Plan

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Cover Page Footnote

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STEM Shift Action Plans

By Nancy Ledbetter

Introduction

Transitioning from a general education program to a STEM program requires changes at every level within the school. Making the shift includes challenging how things are currently being done and being willing to take the plunge into a new way of thinking and doing (Myers & Berkowicz, 2015). These challenges range from misunderstandings about what STEM is to lack of resources for STEM instruction. STEM has a global aspect that no other educational reform efforts have had to consider (Bybee, 2013). The students of today are citizens of a world where technology has made it possible to instantly learn about what is happening in other countries and other cultures. There is a growing need to address global environmental concerns as the population increases and resources dwindle. The country is also facing new threats to national security that the cushion of having friendly nations on two sides, and oceans on the other two sides cannot provide protection from, because these threats are based in a technology that knows no borders (Bybee, 2013). These plus an ever-growing need for an innovative, skilled, and global workforce that is capable of filling the need for occupations that do not yet exist provides the impetus for creating sweeping and unique reform strategies (Bybee, 2013). It is important to start young so that by the time students reach high school they will have a strong understanding of STEM and how to work through problem-solving challenges and inquiry based activities (Myers & Berkowicz, 2015). Therefore, the shift should begin at the early elementary level, starting with the pre-kindergarten through second grade years, and then each year a new level should be added so that by the end of four years the shift to a STEM curriculum will have begun at every level between pre-kindergarten and twelfth grade. Such a dramatic shift caused by this need for multilayered reform causes turbulence at every level within education. This turbulence centers around a need to train educators, a need to reimagine schedules, a need to meet curriculum demands, a need to reallocate resources, and a need to adhere to local, state, and national policies (Johnson, 2011).

Required Changes

To meet these needs and quell the turbulence, change must take place in a methodical manner. The shift starts with the educators. It only takes one to start the shift. One educator with a vision of what could be and the passion to follow through (Myers & Berkowicz, 2015). One educator, however, does not make a STEM school. Everyone else must also be brought up to speed. This requires training. To make sure this is quality training it is important to know what the teachers already know (Han, Yalvac, Capraro, & Capraro, 2015). In general, teachers have little opportunity to receive training in more than one pillar of STEM and lack confidence in their abilities to teach STEM (Honey, Pearson, & Schweingruber, eds., 2014). It is not simply a shift in content knowledge, but also in how content is delivered that teachers must adapt to. Implementation of an integrated STEM curriculum must come about in stages that include teacher training (Bybee, 2010). Teachers have to have confidence in their understanding of the engineering design process if they are to develop strong lessons and activities (Avery & Reeve, 2013). Professional development for teachers and administrators can be the catalyst for taking educators out of their comfort zone and transitioning them into the effective use of an integrated STEM curriculum (Nadelson, Seifert, & Hendricks, 2015). Once teachers become experts in specific areas of STEM integration and instruction they need to be encouraged to share their expertise with others (Katzenmeyer & Moller, 2009)

The next change that must take place is reimagining the schedule. While more challenging at the high school and middle school levels, it can be accomplished, just as it can at the elementary level (Myers & Berkowicz, 2015). Time must be made for STEM. Trying to crowd another period exclusively for STEM in an already overcrowded schedule is not practical. A STEM schedule needs to be fluid enough to allow the teachers to rearrange their day to make lessons and activities to flow naturally (Myers & Berkowicz, 2015). Time must be used to maximum advantage for both students and teachers. Teachers have to have time to plan, organize, analyze, and reflect on the lessons and activities they create for use in the classroom. Students need to be engaged in problem solving and inquiry based learning that incorporate the skills from all disciplines and that will take rearranging the traditional schedule away from set blocks of time dedicated to single subject areas (Myers & Berkowicz, 2015).

When redesigning a school into a STEM school, one important consideration is how the curriculum looks from one grade level to the next (Basham, Koehler, & Isreal, 2011). Early education grade levels would have to be different than upper elementary grade levels, which in turn are different from middle school, and high school would be different from middle school because of the developmental differences in students within age grouping (Gray & MacBlain, 2012). At the high school level, the division of the curriculum into separate and distinct units of studies with students collecting credits in required amounts within different categories, began in the early 1900's and has changed very little since that time (Mirel, 2006). STEM requires those barriers between subject areas be broken down. Problems seldom occur in real life in subject area isolation where they can be resolved by using only math, only science, only technology, or only engineering skills (Bybee, 2013). The skills, typically taught in isolation within individual subjects should be taught as skills necessary for completing tasks and solving problems (Myers & Berkowicz, 2015).

These shifts necessitate a reallocation of resources. Specialty positions are needed. Coaches are a necessity when making the shift to a STEM school (Myers & Berkowicz, 2015). Space within the school needs to be examined based on the need to provide collaboration and innovation areas (Honey & Kanter, eds., 2013). Funding is a major concern when making a STEM shift and deciding where limited funds should go can be tricky because there are materials, equipment, and technologies that are needed. The key is making sure the benefits outweigh the costs (Bybee, 2013). Enlistment of stakeholders within the community is also an essential component of a functioning STEM school (Johnson, ed., 2011). Involving members of the community to support and enhance the program can make the difference in making sure the student population as a whole receives the support and representation (Green, ed., 2014).

A final challenge that could impede a smooth transition is the collective set of local, state, and national mandates. For the district level, it takes meeting face-to-face with the leadership and getting them on board with the program shift so that if allowances need to be made in order to free teachers from specific restrictions or mandates they will understand and support those needs (Johnson, ed., 2011). For state and national matters, it takes a thorough understanding of the expectations and knowing what must be done versus what is suggested be done. STEM is flexible enough to fit nearly any mandate or regulation, but planning must take place in order to make sure that every requirement is met (Bybee, 2013).

The Shift to STEM Action Proposal

The chart that follows will outline the action plans for tackling the five challenges encountered in the transition from a general education school to a STEM school. These steps would be repeated for each level of education taking part in the shift. The first challenge is to train the educators and make sure they have the self-efficacy and skill level in STEM required for success (Blue, 2014). The second challenge is to develop a curriculum that integrates STEM throughout and shows the functional relationship between subject area skills (Green, ed., 2014). The third challenge is to create a schedule that will accommodate the STEM education goals and support the program. The fourth challenge is to make sure the resources are allocated with equitable distribution to make sure all students will benefit from the program. The fifth and final challenge is to analyze the plan and assess the program to make sure all mandates from local, state, or national regulatory agencies have been met.

Each part of the plan is imperative to a successful implementation of a shift to STEM. Properly trained teachers can make a significant difference to the success of a STEM program and to student achievement (Han et al, 2015). STEM professional development can also influence the successful development of a STEM curriculum and provide a strong foundation of lessons and strategies (Avery & Reeve, 2013). The curriculum influences the schedule because students need adequate time to engage in problem solving and inquiry activities (Myers & Berkowicz, 2015). Developing a plan for allocation of resources is imperative because all students need support, the program needs to be sustainable, and must be allowed to grow (Green, ed., 2014). Making sure all requirements of local, state, and national regulatory agencies are met from the start is imperative because a program cannot function if it is constantly having to adjust to account for unaccounted for mandates (Bybee, 2013).

Change Theories

Making the sort of change necessary to move from a general education school to a STEM school takes major adjustments on the part of all stakeholders. Change can be difficult, but without change growth is not possible. Taking change on requires acknowledging that different people will handle change differently when they are required to make a major shift in what they are doing. Training, seminars, and other methods of enlightening the stakeholders involved in the

STEM shift can help make the transition easier because participants will develop a deeper understanding of what changes will be taking place and why the changes need to be made (Avery & Reeve, 2013).

Action change theory addresses behavioral change and uses a needs assessment at the start. This identifies a specific behavior that must be changed and then allows for strategies to be developed that target that behavior. The strategies are then put into place and used consistently until behavior change is achieved (Vlaev & Dolan, 2015). This applies to making a shift to a STEM model because students and teachers have to adapt to a new way of learning and teaching. Every individual in a school about to undergo a major transition is affected, from the bookkeeper who must rethink what supplies are necessary, to the district superintendent who must rethink what learning looks like in the classroom.

There is no change that can happen that does not result in some kind of loss. The human dynamics and change theory helps minimize the loss and maximize acceptance of the change. (Austin & Currie, 2003). This theory proposes that instead of approaching the shift as a change, it should be taken on as a transition. Transitions happen more gradually, it is achieved internally, and takes into account how individuals feel, think, and react to shifts in the workplace (Austin & Currie, 2003). In education, these emotional responses to change can affect the success or failure of a program. If the educators do not have a chance to adapt the idea of STEM before they are asked to give up what they are used to doing, it could result in feelings of panic, fear, loss, and corresponding reduction of productivity and confidence (Austin & Currie, 2003).

Dynamic capabilities theory combines both theories of strategy and theories of change. Strategic theory focuses on scope, performance, and behaviors, while change theories focus on cause, objectives, processes, and outcomes (Schweizer, Rogbeer, & Michaelis, 2015). This makes the dynamic capabilities theory particularly appropriate for making a systemic shift within a school. This theory includes having to reallocate resources to maximize efforts towards the new organizational goals, shifts in operational procedures such as scheduling changes, and staying fluid in terms of procedures and assessments (Schweizer, Rogbeer, & Michaelis, 2015). This sort of dynamic change applies to adapting teaching strategies and using the latest tools available for teaching.

Bhola's configurations theory of planned change gives individuals involved three epistemic ways to view the changes taking place. One method is systemic thinking, which looks at the relationships between the separate pieces that make up the whole as well as the whole itself (Schwartz & Tiffany, 1994). In a school making a STEM shift, this would be a view that considers the school as a whole, the students, the curriculum, the teachers, the equipment, the lessons, and the rest as the parts that make up the whole. The second method is dialectical thinking. Dialectics looks at opposing views and tries to bring them together (Schwartz & Tiffany, 1994). Within a school making a STEM shift these opposing views can occur when there is no clear understanding of the goals of the school, and an unclear vision of how to achieve the new goals. Training and dialogue have to happen to bring people together. The third method is constructivist thinking where people take parts of the old system that work and build upon that to create a new ways to do things (Schwartz & Tiffany, 1994). In an educational setting this would mean that teachers should keep what has been proven to work and build upon that.

Using data to determine what needs to be done to accomplish goals is the basis for grounded theory of change. For change to be purposeful it should be based on data that indicates what has been shown to work (Sune & Gibb, 2015). School systems focus on data. There is not a monetary measure that shows if a process is successful, but test scores are used in much the same way as financial balances in education. Students must be show growth in test scores for a school to be considered successful. Therefore, with the grounded theory of change, selected strategies need to have data to support their use when making a shift.

Challenge	Steps	Constraints	Benefits
Educator Training	1. Identify the purpose for STEM education (Bybee, 2013). 2. Assess current readiness of educators in the targeted grade levels (Han et al, 2015). 3. Provide in depth and ongoing content and strategy based professional development (Green, ed., 2014). 4. Encourage teachers to take on leadership roles in training each other (Katzenmeyer & Moller, 2009).	Time for teachers to train before the school year begins and continuing forward. Funding for bringing teachers in for the summer, for bringing in experts, and for funding coach positions.	Students will benefit from well trained teachers who present high quality lessons and activities (Han et al, 215). Teachers will have higher levels of efficacy and will produce higher quality learning experiences (Green, ed., 2014).
Challenge	**Steps**	**Constraints**	**Benefits**
Curriculum development	1. Develop a planning team (Myers & Berkowicz, 2015). 2. Establish the goals and objectives for learning, then define the strategies to use to reach the goals (Honey & Kanter, eds., 2013). 3. Design student centered learning STEM integrated experiences that use problem-based learning and inquiry (Bybee, 2013). 4. Assess and redesign as needed to make sure the curriculum is high quality (Myers & Berkowicz, 2015).	Existing regulations and requirements. Facility limitations for learning space. Availability of highly trained STEM educators. Administrative support and encouragement.	1. Highly engaged students who develop lifelong skills and interests in STEM (Myers & Berkowicz, 2015). 2. Students develop an understanding of how STEM skills and learning overlap and are used together (Honey & Kanter, eds., 2013).

Challenge	Steps	Constraints	Benefits
Schedule Creation	1. Determine the non-negotiable parts of the schedule, such as lunch, special services, and the specific school day hours of operation (NC DPI, 2003). 2. Use the goals and planned activities to create a schedule that allows for subject area integration and collaboration between teachers and students (Myers & Berkowicz, 2015).	Time must exist in the schedule to allow for collaboration, exploration, and inquiry. Perceptions must be altered to make the shift from a traditional school day to one where block scheduling and integrated curriculum can flourish.	1. All students have the opportunity to develop STEM literacy skills (Glancy & Moore, 2013) 2. Time exists for students to fully engage and develop an understanding of the targeted skills (Myers & Berkowicz, 2015).
Challenge	**Steps**	**Constraints**	**Benefits**
Resource Allocation	1. Identify all available resources (Green, ed., 2014). 2. Create a plan for use of the resources (Green, ed., 2014). 3. Create a budget for covering program expenses (Green, ed., 2014).	Facilities at the school must be adequate to support inquiry and collaboration. Personnel must exist to support and cover the classrooms and collaborative spaces.	1. All students benefit from all available resources (Myers & Berkowicz, 2015). 2. A sustainable STEM program will be established (Myers & Berkowicz, 2015).
Challenge	**Steps**	**Constraints**	**Benefits**
Curriculum Alignment	1. Identify existing regulations and requirements at the different levels. 2. Discover which requirements are mandatory and which are negotiable. 3. Develop a committee to review lessons and activities to makes sure they align to the required standards (Bybee, 2013).	Requirements from local, state, and national agencies. Administrative support for allowing teachers to divert from traditional approaches to STEM integrated methods of instruction.	1. Students will learn required skills and be ready for mandated assessments (Myers & Berkowicz, 2015). 2. All stakeholders will understand how the newly designed curriculum will be a benefit (Myers & Berkowicz, 2015).

Personnel and the STEM Shift

The selection of who should be in charge of each plan must be done with care and precision. The first action plan regards professional development. The person in charge has to have a clear vision of the goals of the school as a STEM school. While the principal must set the vision, the principal is also going to be tied up with concerns that affect the school as a whole and monitoring every aspect of the shift, therefore, having an instructional coach or a STEM specialist in charge of staff development is more practical. This STEM coach should have a strong foundation in and understanding of STEM (Green, ed., 2014). The action change theory applies to the first action plan because teachers have to give up the traditional classroom approach and embrace a new way of doing things. Teachers will be more successful if they can take small steps towards changing how they teach and action change theory is about getting people, in this case teachers, to make changes to what they do (Vlaev & Dolan, 2015). The human dynamics and change theory is also applicable to this first stage of STEM shift, because it is the transitional phase (Austin & Currie, 2003). Teachers cannot be expected to go to a single, in depth, professional development session and emerge as experts. They must be given time to absorb and work with what they are learning. It will take time for some teachers to accept that they must let go of some practices. This letting go of the ways of old must be accounted for and planned for. The STEM coach has to be alert for symptoms of loss that could interfere with instruction. The principal and the STEM coach must be able to communicate and conference with teachers who are not on board with the shift. It could be that the principal might have to make a decision about whether that teacher is right for the school under its new STEM umbrella. This is because the principal must be able to trust the teachers to support the STEM vision for the school (Myers & Berkowicz, 2015). Teachers must also be able to reach out to the STEM coach for support as they put their plans into action and discover what works and what needs tweaking or what they need more assistance with (Avery & Reeve, 2013).

The next action is the development of the curriculum. This should be monitored by the school instructional coach and the STEM coach, however, each grade level needs to have a teacher leader who is responsible for overseeing curriculum development. Since the overall plan calls for the early grades to make the shift first, that is the grade level set that needs to be focused on before school begins for students. Bhola's configurations theory of planned change is particularly applicable because the teacher leaders at each grade level need to look at the shift from all three views, systemic, dialectic, and constructionist (Schwartz & Tiffany, 1994). The teacher leaders have to look at the curriculum not only from the point of view of their own grade levels, but also from the grade levels that come immediately before and after so they do not spend time developing curriculum that repeats what has come before and fails to consider what students need to be prepared for next (Myers & Berkowicz, 2015). Each year that passes will see the addition of new educational levels into the STEM shift and new teacher leaders will have to be given the opportunity to step up and take the lead in helping to develop the curriculum for their grade levels (Katzenmeyer & Moller, 2009).

The principal must take charge of supervising the scheduling change, because the principal is ultimately responsible to the district for making sure non-negotiable fixtures are addressed in the schedule. The principal should work with the school improvement team in order to get input from all the stakeholders (Myers & Berkowicz, 2015). The change theory that most relates to this endeavor is the dynamic capabilities theory because the schedule has to take into consideration the necessary systemic change required by shifting to an integrated STEM schedule (Schweizer, Rogbeer, & Michaelis, 2015). This plan of action must happen once the general plan for the curriculum is laid out but before it is finalized. This is because the committee must have an idea of what the curriculum is going to require, and those developing the curriculum must know the allocation of time available to them.

The people responsible for resource allocation are myriad. Overall, the principal must ultimately be in control because resources include personnel, finances, materials, equipment, volunteers, community connections, and other things that go into making a school function at top performance levels (Bybee, 2013). Each category of resource needs a person to oversee it that reports to the principal. The STEM coach working with the media specialist could be in charge of making sure the necessary equipment and materials are available to teachers as they need it. The school treasurer or bookkeeper would be in charge of tracking expenditures. A volunteer coordinator would be in charge of keeping track of community resources and volunteers. An instructional coach could make sure teachers are using appropriate strategies and could work with the STEM coach to make sure professional development is ongoing. All of these people combined would make up a strategic committee reporting to the principal. The first thing the strategic committee would have to do would be to work to make sure the teachers were being trained, the next thing would be for them to make sure teachers had the tools and materials they needed to make their plans come to fruition stakeholders (Myers & Berkowicz, 2015). This action plan would have to be happening simultaneously with all of the other plans.

Finally, the action plan concerning making sure the curriculum is aligned to district, state, and national regulations could fall to an assistant principal in charge of instruction and the instructional coach. These individuals would have to monitor lesson plans to make sure that problem-solving and inquiry were in use in effective ways that promoted STEM literacy and state standards and objectives (Myers & Berkowicz, 2015). This pair would use the grounded theory of change and would rely on data to help determine if lessons were effective and were working (Sune & Gibb, 2015). This action plan would go into effect as curriculum is being developed and would continue to assess curriculum changes as they occurred.

Conclusion

Teachers involved in shifting a school to a STEM school must have or must develop an understanding of how STEM disciplines relate not only to each other, but to all other subject areas (Glancy & Moore, 2013). To achieve this understanding to the depth necessary, teachers must work together to train via staff development opportunities and specialized training. STEM professional development needs to include a focus on engineering and technology to insure they understand the process and the tools available for creating meaningful problem-based learning experiences (Avery & Reeve, 2013). A STEM curriculum must be designed that meets the needs of the school and the requirements of local, state, and national standards. This curriculum should be designed with input from the teachers if the change is going to be done as a smooth transition and fully utilize all the available resources while still making sure everyone is working together towards the same common goal (Schwartz & Tiffany, 1994). Resources have to be properly allocated. The schedule has to make time for students and for teachers to collaborate and create (Myers & Berkowicz, 2015). Shifting to a STEM school from a general education or traditional school absolutely requires that teachers understand what STEM is and how to engage students while still covering the standards and this requires training. The shift to a STEM school also requires that an integrated curriculum be developed because the traditional educational approach keeps the subject areas in isolation, a completely unrealistic approach, as problems in life involve overlapping content knowledge and skills to resolve (Bybee, 2013). Accommodating this new curriculum requires adjusting the schedule, because a STEM curriculum requires students have time to collaborate, investigate, and test theories, and that cannot happen is a short single subject block of time (Myers & Berkowicz, 2015). If done correctly, the STEM shift will result in a school where teachers are collaborating, the curriculum is integrated, and the students are engaged in their learning.

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