Published in final edited form as:

Educ Technol Res Dev. 2020 October ; 68(5): 2595–2614. doi:10.1007/s11423-020-09782-5.

Development of a competency model and tailored assessment method for high school science teachers utilizing a flipped learning approach

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Abstract

Many professional development programs aim to improve student outcomes by enhancing teacher competencies. Effective evaluation of these programs requires a clear delineation of the competencies to be gained. A competency model was developed to evaluate the impact of a teacher professional program that aimed to improve teachers' ability to effectively implement technologically engaged modules in a flipped classroom setting. Competencies were identified via

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Conflict of Interest

Marie Barnard: The author declares no conflict of interest.

Erin Dehon: The author declares no conflict of interest.

Caroline Compretta: The author declares no conflict of interest.

Andrew Notebaert: The author declares no conflict of interest.

Wesley Sparkmon: The author declares no conflict of interest.

Edgar Meyer: The author declares no conflict of interest.

Stephan Stray: The author declares no conflict of interest.

Juanyce Taylor: The author declares no conflict of interest.

Donna Sullivan: The author declares no conflict of interest.

Robin Rockhold: The author declares no conflict of interest.

Ethical Approval

All procedures performed in studies using human participants were in accordance with the ethical standards of the institutional research committee (University of Mississippi Medical Center Institutional Review Board protocol #2016–0109) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

participatory evaluation techniques and assessments were aligned to the competencies. The competency of teachers in the knowledge, skills, and abilities needed for creation and delivery of effective flipped lessons can be tracked using a radar graph to guide tailored professional development.

Keywords

Competencies; Flipped Learning; Professional Development; STEM education

Introduction

Schools are challenged to offer high-quality science education for all students as the need for understanding of science and technology in today's society increases. The Next Generation Science Standards specify what students should know and be able to do in science at particular grade levels (National Research Council, 2013). As science educators respond to the vision of science education for which the Next Generation Science Standards calls, including classrooms that bring science alive for students (National Research Council, 2013), there is a need to provide professional development so teachers can successfully enhance STEM (Science, Technology, Engineering and Math) learning experiences. For many educators this development will focus on pedagogical techniques, not just science content knowledge. Indeed, the National Academy of Sciences found that the growing understanding of how to best teach science would require a significant transition in how science is taught in classrooms, requiring most teachers to evolve how they teach (National Academies of Sciences, 2016).

Many professional development programs aim to enhance teachers' abilities, with a goal of ultimately improving student outcomes. To close the gap between the new way of teaching science and the current instructional methods used in most schools requires personalizing development opportunities for teachers (National Academies of Sciences, 2016). However, tailoring or personalizing development opportunities is challenging. To do so requires the ability to determine where an individual teacher is in regard to the knowledge, skills, and abilities the program targets. To effectively evaluate professional development programs requires a clear delineation of the competencies to be gained through participation in order to determine potential growth or enhancement. This project sought to develop a competency model and an associated assessment framework to facilitate the provision of individually tailored, actionable feedback for STEM teachers participating in a professional development program focused on flipped classroom pedagogy and health and obesity-related science content.

Literature review

This study was framed based on concepts associated with teacher competency. A summary of the literature that provided the framework is presented, followed by a description flipped learning pedagogy and the program in which this study is based.

Competencies

Student outcomes, from learning outcomes to enrollment in higher education and future salary, are impacted by teacher competence (Chetty et al., 2013). Blömeke and Delaney (2012) developed a conceptual framework of teacher competency that included both cognitive abilities and affective-motivational characteristics (Blömeke and Delaney, 2012). This framework incorporated work by Shulman (1985) that distinguished three different types of knowledge. Blömeke and Delaney's framework included these three types of knowledge under the domain of cognitive abilities and identified them as content knowledge, pedagogical content knowledge, and general pedagogical knowledge. Content knowledge is knowledge of the specific discipline (e.g., knowledge of biology), whereas pedagogical content knowledge is knowledge about the teaching and learning of the discipline (e.g., knowledge about teaching and learning biology). General pedagogical knowledge is knowledge about teaching that is not subject-matter specific. The affective-motivational characteristics in Blömeke and Delaney's framework include professional beliefs and professional motivation and self-regulation. Teacher beliefs connect knowledge and action; beliefs about the content being taught and about the situation in the classroom provide a link between an individual teacher's beliefs and the achievement of his/her students (Blömeke and Delaney, 2012; Bromme and Steinbring, 1994). This framework posits that a teacher that is motivated regulates behavior in order to achieve professional objectives and will utilize appropriate strategies in order to do so (Blömeke and Delaney, 2012).

Flipped learning

The flipped learning approach, which has gained considerable attention in both K-12 and health sciences education, increases student openness to engaging both cooperative learning and innovative teaching (Bishop and Verleger, 2013; Mortensen and Nicholson, 2015). This pedagogical method 'delivers' content differently than traditional classroom lecture (Baker, 2000; Lage et al., 2000). Flipped learning moves the primary delivery of content outside of the classroom, through videos or other methods. In-class time is then used for collaborative, active learning activities relevant to the lesson content. Students have reported they like the flipped learning approach (Butt, 2014; Clark, 2015). Importantly, this instructional approach requires different preparation and classroom management techniques compared to traditional pedagogical methods. Flipped learning requires that teachers physically rearrange learning spaces, shift to a learner-centered approach, intentionally build content, and take on an even more demanding classroom role as they observe and provide feedback relevant in the moment (Flipped Learning Network, 2014). The skills, knowledge, and ability to successfully implement a flipped learning approach require specific competencies that this study intends to identify.

Program description

According to America's Health Rankings, Mississippi ranked 50th in overall health outcomes, social determinants, and economic factors impacting quality of life in 2018 ("America's Health Rankings Annual Report, 2018," 2018). Persistent challenges in the state include excessive drinking, physical inactivity, poverty, and early death rates. In the past three years, obesity increased by 15% from 28.8% to 33.1% of adults aged 65 and older.

The Mississippi State Department of Health reported that 18.9% of Mississippi public high school students were obese, compared to 13.9% nationally (Vargas and Zhang, 2017). In addition, 22.9% of Mississippi students did not participate in at least 60 minutes of physical activity on any day during the past seven days, compared to the national average of 14.3% (Vargas and Zhang, 2017). There is a compelling need to offer secondary science education that can increase students' awareness and knowledge of these issues in order to decrease negative health consequences.

The Science Teaching Excites Medical Interest (STEMI) program was developed to address this need (Notebaert et al., 2018). STEMI is a collaboration of university-based faculty at the University of Mississippi Medical Center (UMMC), graduate students in the UMMC Clinical Anatomy degree program, and Mississippi secondary schools. The STEMI program seeks to develop a technologically enhanced teacher-centered community of health learners, with a specific focus on preparing teachers to utilize a flipped learning approach. The STEMI community is developing, implementing, and disseminating flipped learning modules focused on obesity and health disparities for use in high school science courses. The program recruits science teachers from public and private high schools across the state. A core group of experienced teachers, STEMI Cadre Prime, who have been engaged in a long-term partnership with UMMC is part of the leadership team for the project. Each year a new 'cadre' of teachers is recruited to participate in a two-year professional development program delivered by the leadership team that offers exposure to technologies and curriculum elements essential for successful implementation of flipped lesson/classroom (FL/C) science instruction. Two consecutive summer workshops include flipped lesson modeling, lectures, problem-based learning, hands-on activities, skills training, and collaborative professional development activities in both the basic sciences and educational practices. Continuing support during the academic year is provided by the leadership team through a regular schedule of teleconferences and sponsored trips for teachers participating in the program to professional scientific and educational conferences. These activities strengthen partnerships, reinforce learning, and promote continuous professional development with an ultimate goal of improving science education and through that the health of Mississippians. The STEMI program seeks to improve teacher quality by developing the competencies in science teachers needed to effectively implement flipped classroom technologically-engaged modules on obesity-related topics.

Purpose of study

The aim of this effort was to engage in a teacher-driven process to address the following questions:

1. What are the competencies needed to engage in effective flipped learning pedagogy?
2. How can individual progress toward the identified competencies be assessed and tracked?

Methods

Participants

Participants involved in the development of the competency model included university faculty with expertise in science education and a variety of scientific disciplines and the STEMI Cadre Prime teachers. The six 'Cadre Prime' high school science teachers all have more than two decades of experience in secondary science education and are recipients of multiple teaching awards. Table 1 describes these teachers, including their experience, training, and awards. This group of teachers has been engaged in a variety of professional development efforts in conjunction with university faculty for more than a decade. Among the teachers, there are individuals with doctoral training in science education pedagogy, individuals who have independently created national teacher training programs, and individuals with extensive experience in preparing, delivering, and evaluating the effectiveness of flipped learning lessons. The Cadre Prime teachers worked collaboratively with a team of six STEMI investigators with experience in science pedagogy at the high school, undergraduate, graduate, and health science professional levels. In addition to the faculty, a doctoral student in clinical anatomy with previous teaching experience in the high school environment participated in the development of the competency model. The clinical anatomy program trains doctoral students as anatomy educator-scholars and supports research in the development of novel teaching tools and approaches.

Identification of competencies

The team utilized a modified Delphi approach, engaging in a collaborative teacher-driven effort, to develop the comprehensive set of competencies for STEMI teachers (Helmer, 1967). A five-step process was utilized to develop the competencies (Figure 1). First, the Cadre Prime teachers responded individually to open-ended questions that asked what they thought were important skills, knowledge, and abilities that a teacher would need to be able to successfully develop and implement a flipped learning module aligned with Next Generation Science Standards on health concerns directly impacted by obesity. The responses generated a large list of constructs. Next, the evaluation team collated the responses and shared the list with the STEMI investigators and teachers via an online questionnaire in which they were presented with all of the responses (48 non-duplicative responses) and asked to rate each one on a scale that ranged from "definitely not a necessary competency" to "definitely a necessary competency." In addition, the respondents were asked to review the list and to consider if there were any missing constructs and suggested any potential additions, identifying nine new constructs. The results of this process were then shared with the group to review the ratings, as well as to develop domains into which the constructs could be grouped. This process was repeated twice to enhance convergence on a smaller number of constructs. Third, a retreat was held in which a consensus building approach was utilized to refine the domains, further synthesize constructs, and to separate STEMI competencies from general teaching competencies. A review of literature, focused on the Blömeke and Delaney model that provided the guiding framework, was then conducted to inform and support further refinement of the domains and competencies to support assessment development, followed by a final review by the teachers and investigators. Lastly, the STEMI investigators completed a review to systematize language.

The Dreyfus Model was utilized to assign levels (novice, intermediate, and advanced) to competency acquisition levels for each competency in all of the domains (Batalden et al., 2002; Dreyfus, 2004). Specific behavioral criteria are utilized to define each standard level.

Institutional Review Board approval was granted prior to the initiation of this project and informed consent was obtained from all individuals involved in the development of the competency model.

Findings

A total of 27 competencies were identified and were clustered into six domains (Table 2). The first domain, *Attitudes Toward Flipped Learning and Teaching in STEM*, encompasses competencies associated with willingness to engage in efforts to effectively teach STEM courses in a flipped learning environment. These competencies are indicative of teachers' professional beliefs and motivations, specifically relating to teaching STEM content in a flipped learning method. Confidence, being receptive to feedback, and engagement in a community of learners were identified as essential affective factors that drive willingness to work toward being an effective STEM teacher who utilizes flipped learning techniques.

The second domain, *Knowledge Application*, includes competencies that demonstrate the application of knowledge of flipped learning, appropriate health sciences content, and best practices in teaching to develop lessons that are aligned to standards and represent a coherent sequence of learning. This pedagogical content knowledge domain incorporates four specific competencies. Importantly, the ability to employ inquiry-based STEM activities to complement and extend material outside of the classroom setting was endorsed as a critical competency.

The third domain, *Instructional Professionalism*, includes competencies related to implementing, evaluating, and disseminating flipped learning STEM instruction and instructional materials. The fourth and fifth domains are generally related to pedagogical knowledge. The domains were separated to make clear that this type of professional development program had a specific focus on the use of technology in teaching and thus a unique domain for technology competencies was created. The *Learning Environment Management* domain includes competencies that are associated with the ability to implement effective pedagogical practices to support active learning in a flipped learning environment. Modeling to facilitate student success, is a readily recognizable pedagogical practice. In this kind of professional development program, modeling how to utilize the technology resources students need to complete the flipped portions of lessons is the focus. The *Technology Skills* domain incorporates the use of technology in both traditional teaching components, such as assessments, as well as in the creation of lesson materials, such as videos. The final domain is a content-knowledge domain of health-related content, including competency in health data, health literacy, and causes and associated health consequences of obesity.

Assessment of the competencies

Once the competencies were identified, assessments were mapped to the competencies to capture individual growth in each of the competencies throughout program participation (Table 3). This step was necessarily conducted after the development of the competencies. For each specific competency, a method was sought that would facilitate an understanding of individual growth. Where possible, standardized instruments were utilized. Additional consideration was given to having a multi-modal assessment battery (e.g., self-report, observations). Assessments include standardized assessments (Science Teaching Efficacy Belief Instrument, Teaching Practices Inventory, Teacher Self-Efficacy Scale, Health Literacy Skills Instrument), knowledge assessments, document reviews, structured observations, and self-assessments (Enochs and Riggs, 1990; McCormack et al., 2010; Tschannen-Moran and Hoy, 2001; Wieman, 2015).

Competencies in the first domain, *Attitudes Toward Flipped Learning Teaching in STEM*, were assessed with a mix of standardized self-report instruments, observations, and documentation as described in Table 3. The first standardized instrument, the Teacher Self-Efficacy Scale (TSES) which measures confidence in effectively influencing the engagement and learning of all students, was utilized to measure general confidence in teaching capability (Tschannen-Moran and Hoy, 2001). The Science Teaching Efficacy Belief Instrument (STEBI) measures this factor as it specifically relates to teaching science (Enochs and Riggs, 1990; Riggs and Enoch, 1990). Structured observations and document review were the primary evaluation tools for the *Instructional Professionalism, Learning Environment Management, and Technology Skills* domains. Observations utilized the Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2002). The RTOP was designed by an evaluation team to support a standards-based, student-centered, inquiry-oriented observation protocol to assess National Science Foundation projects focused on excellence in teacher preparation and has been utilized in hundreds of teacher preparation and professional development projects (Sawada et al., 2002). Additional items were added to capture specific competencies not covered in the RTOP (e.g., details of multimedia utilization and digital assessment tool utilization). The Health Content domain is assessed with the Health Literacy Skills Instrument and observation. The Health Literacy Skills Instrument is a publicly available measure that assesses an individual's comprehension, print and oral literacy, numeracy, and ability to seek health information through the internet (Bann et al., 2012; McCormack et al., 2010).

Teacher self-assessments and document reviews are conducted three times a year and each teacher is observed at least once per year. The assessments are then utilized to provide data on each of the competencies. Each individual teacher's data is graphed as a radar graph that demonstrates where the teacher is on all of the individual competencies in a single graph. This tool is a useful method to assess competencies and provide feedback for continued professional growth (Harrington et al., 2015; Keister et al., 2012).

Radar graphs for two of the STEMI teachers demonstrate how this assessment approach can be used to guide tailored professional development for individual teachers in the STEMI Program. In Figure 2 Teacher A from Cadre Prime is rated intermediate on six competencies and advanced on the others. Teacher B from the initial group of teacher participants (Cadre

1) is rated as a novice on seven competencies, intermediate on nine, and advanced on six others. Tailored activities to facilitate growth for each of these competencies to move them from novice to intermediate or intermediate to advanced can be planned for the next year of their participation, while utilizing the teachers who had participated in the program in previous years to support novice teachers on competencies for which they are advanced. The trajectory of development of competencies will provide new data on how teacher professional development translates into competencies observed in the classroom.

Discussion

Preparing science educators to deliver a high quality, best practice-based, active learning environment is imperative for improving science education. This project developed a competency model that could be used to evaluate the impact of a professional development effort to prepare teachers to utilize a flipped learning approach to teaching about obesity-related topics in STEM courses. The competency model that was developed for STEMI was informed by Blömeke and Delaney's framework and the constructs they incorporated associated with teacher competency (Blömeke and Delaney, 2012; Richardson, 1996; Shulman, 1986; Thompson, 1992). The Blömeke and Delaney framework incorporated content knowledge, pedagogical content knowledge, and general pedagogical knowledge in the cognitive abilities domain. Just as in their framework, our competency model incorporates content knowledge (*Health-related Content*), pedagogical content knowledge (*Knowledge Application*), and general pedagogical knowledge (*Learning Environment Management*). We also identified similar domains as the affective-motivational characteristics in Blömeke and Delaney's framework. Our model includes *Attitudes Toward Flipped Learning and Teaching in STEM*, which is similar to their professional beliefs and self-regulation but specific to technologically engaged STEM teaching. Finally, we identified a domain, *Instructional Professionalism*, that is similar to their professional motivation construct. Our competency model extends their work by providing specific competencies beyond identification of the domains, as well as identifying methods to assess individuals on each competency. Our effort was also a teacher-driven process, further enhancing the validity of the identified domains and competencies.

STEMI project participants identified competencies that included attitudinal, knowledge, and skill components. These competencies include factors that go beyond classroom and instruction related factors to professional engagement, such as participation in a community of learners and demonstration of the value of flipped learning techniques to other teachers. The competencies make clear that implementing a flipped learning pedagogical approach requires more than changing how material is communicated to students. Effective implementation of flipped learning requires teachers to manage classroom spaces in a different manner and to model the use of technology (Flipped Learning Network, 2014).

The STEMI competency model developed is easily adaptable to professional development programs that target different content areas. This is one of the strengths of this competency model as it provides specific guidance regarding attitudinal, knowledge, and skills needed for this pedagogical approach, and it still remains flexible for use in multiple disciplines. Of the six domains in the model, the sixth domain is content-specific and could be altered based

on the topical focus for any given curriculum. Assessment of this domain can then be tailored to the content area for which it is being applied.

There are several additional strengths of this effort. First and most importantly, the development of the competency model was a collaborative teacher-driven process. Having the teachers involved in the design of the competencies and assessment process resulted in a product is focused on the needs of the teachers. Additionally, being involved allows the teachers to work together with varied levels of educational experts and centers them as leaders, informing decisions that govern teaching, learning, and student outcomes. Active teacher engagement, through the use of collaboration and participation in learning communities, yields more effective teaching and improves student achievement (Fulton and Britton, 2011). A second strength is the adaptability of the model, as competencies related to content were purposefully identified as one domain that could easily be replaced with a different content area. Further study of this model with other domains would be valuable. An additional strength is that the model can detect progress over time and can reflect a full range of performance.

There are limitations to the current effort. The competency model was developed for use with a specific project and has not yet been tested in other settings. Additionally, the teachers engaged in the development process all teach in the same state.. All individuals who participated in the development of the competency model, including the clinical anatomy graduate student, are engaged in the STEMI program

Conclusion

Understanding teacher competencies related to health and flipped learning pedagogy is critical for ensuring that professional development efforts prepare them to successfully optimize student outcomes. This study sought to determine what are the competencies needed for STEM teachers to engage in effective flipped learning pedagogy, as well as how individual teachers' progress toward the identified competencies can be assessed and tracked. By documenting a method by which these competencies can be elucidated through a teacher-driven process, this research contributes to the literature that can support effective science education. This competency development technique could be useful to other professional development programs seeking to evaluate the effectiveness of programs. The radar graph technique to track growth over time can also benefit professional development efforts. Future studies should examine whether the competency model developed here can benefit professional development efforts on other topics and in other regions.

Acknowledgements

The STEMI investigators would like to thank the teachers who have participated in the STEMI program. Their dedication and professionalism have a daily impact on the lives of Mississippi students, and it is inspiring to work with them.

Funding

This work was supported by a Science Education Partnership Award (SEPA) grant, Grant Number 8 R25GM129212-03 from the National Institutes of General Medical Sciences (NIGMS), National Institutes of Health (NIH). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIGMS or NIH.

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Dr. Erin Dehon (ORCID iD: 0000-0003-2833-1306) is an Associate Professor and Director of Faculty Development and Behavioral Science Education in the Department of Emergency Medicine. She is a licensed clinical psychologist with specific training and expertise in evidence-based treatments for mental health conditions, behavioral and psychological assessments, and quantitative survey research using social-psychological variables. Her research and professional interests include faculty development, medical education, program and performance evaluations, physician wellness, and health psychology. She has published several articles and received grant funding on topics related to medical education.

Dr. Caroline Compretta (ORCID iD: 0000-0002-7916-386X) is an Assistant Professor in the Departments of Preventive Medicine and Pediatrics in addition to being Core Faculty in the Center for Bioethics and Medical Humanities. As an anthropologist, she has developed and implemented medical humanities curricula and experiential learning exercises related to health equity, population health, and health behaviors. Her research interests include social determinants of health, food insecurity, pediatric obesity, and community-based organizations.

Wesley Sparkmon, MPH (ORCID iD: 0000-0002-7918-0248) is a doctoral student in the Department of Pharmacy Administration at the University of Mississippi. His research interests include pharmacy technician training and career advancement, pharmaceutical policy analysis, rural healthcare access, and pharmacy education. He received his BS in Pharmaceutical Sciences from the University of Mississippi and his MPH, with an emphasis in population health management, from the University of Louisville.

Dr. Andrew Notebaert is an Assistant Professor in the Neurobiology and Anatomical Sciences Department at the University of Mississippi Medical Center. He is also the program director for the PhD in Clinical Anatomy program. His teaching responsibilities include Medical Gross Anatomy and several educational courses for graduate students. His research focuses on learning in the anatomical sciences and student perceptions of health science education.

Dr. Edgar Meyer (ORCID iD: 0000-0003-3748-7644) is an Assistant Professor in the Department of Neurobiology and Developmental Sciences at the University of Arkansas for Medical Sciences College of Medicine. His teaching appointment currently includes the Human Structure course which incorporates foundations in clinical skills and pathology into a medical gross anatomy curriculum. His research interests include exploring the impact of virtual three-dimensional (3D) anatomical models and of other technological and

instructional interventions on health sciences students' short- and long-term retention. He is also a former high school instructor, maintaining an active educator license in the state of Mississippi in the disciplines of biology (7–12), chemistry (7–12), and Latin (K–12). He is a recent graduate from the Ph.D. in Clinical Anatomy program at the University of Mississippi Medical Center.

Dr. Stephen Stray received his undergraduate training in Australia at the University of Melbourne, and completed his PhD in Microbiology at the University of Alabama at Birmingham on influenza virus. Following postdoctoral training in immunology and Biophysics, he joined the faculty of the University of Mississippi Medical Center. His research interests include influenza evolution and using viruses to treat cancer. He has been involved in outreach programs with high school and undergraduate students since 2007. He is also extensively involved in preclinical medical education and has a passion for helping students at all levels achieve their educational goals

Dr. Juanyce Taylor was appointed chief diversity and inclusion officer in 2016 to accelerate the integration of diversity and inclusive practices within the University of Mississippi Medical Center's mission areas and workforce. Taylor leads several institutional committees, including the Vice Chancellor's Council on Diversity and Inclusion, Health Care Disparities Council, Institutional Climate Committee, and the Diversity Action and Accountability Review Team. Previously, she served as assistant dean for research and innovation for the School of Health Related Professions (SHRP), chair of the Department of Health Sciences, and director of diversity assessment and programs at UMMC. She maintains her faculty appointment as an associate professor in the Doctor of Health Administration Program in SHRP. Prior to coming to UMMC, Taylor worked at the University of Mississippi and Auburn University leading programs designed to increase student and faculty diversity in STEM fields, and for improving access to higher education and student retention among underrepresented populations. Taylor is from Jackson, Mississippi and received her BS and PhD from the University of Southern Mississippi and her MEd from Jackson State University.

Dr. Donna Sullivan is a co-investigator for the STEMI project. After completing her PhD, she completed a postdoctoral fellowship at Louisiana State University School of Medicine. She served as Professor of Medicine in the Division of Infectious Diseases at the University of Mississippi Medical Center. During her tenure at UMMC, her research included studies of histoplasmosis (*Histoplasma capsulatum*) and blastomycosis (*Blastomyces dermatitidis*), fungal diseases in humans. In addition, she developed digital droplet polymerase chain reactions for detection of methicillin resistant *Staphylococcus aureus* infections, genetic mutations in colorectal cancer as well as nasopharyngeal tumors. She has participated in the Base Pair programs for high school STEM teachers for 30 years.

Dr. Robin Rockhold (ORCID iD: 0000-0002-4079-0057) Rob Rockhold, PhD, FAPE, currently serves as the Deputy Chief Academic Officer within the University of Mississippi Medical Center. In that role, he has primary responsibility for management of the Office of Interprofessional Simulation, Training, Assessment, Research, and Safety (ISTARS) and direction of both the Office of Health Careers Opportunity (student outreach activities) and

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Figure 1.
Competency development process

Figure 2.
Individual teacher radar graphs of competencies

Table 1.**STEMI Cadre Prime Teachers**

Teacher	Key Professional Information
Teacher A	Subjects taught: Microbiology, Genetics, Zoology 1 and 2, Dual Credit Biology, Principles of Biology Years experience: 35 Degrees: B.S. Biology, M.S. Biology Other notables: State Teacher of the Year First Alternate; Jackson Public Schools Teacher of the Year; Mississippi 2 nd Congressional District Teacher of the Year; Jackson Chamber of Commerce Teacher of the Year; Community Partners Teacher of the Year; Mississippi Academy of Sciences Teacher of the Year
Teacher B	Subjects taught: Biology, AP Biology, Chemistry, AP Chemistry, Physics, AP Physics, Physical Science, Biomedical Research, Genetics, Molecular Biology and Principles of Biomedical Research Years experience: 27 Degrees: B.S. Biology, M.S. Science Education, Ed.S. Educational Administration Other notables: Science Department Chair; Science Coach; Professional Learning Community Leader; Faculty Advisory Committee; Leadership Team; Governor's Educational Advisory Task Force
Teacher C	Subjects taught: Chemistry, Biology, A&P, Biomedical Research, Years experience: 33 Degrees: B.S. & M.S. Science Education Other notables: Biotech Training Workshops at Cornell, Harvard, and Princeton
Teacher D	Subjects taught: Chemistry, AP Chemistry, Biology, Physics, Biomedical Research, Field Experiences, Biology II Years experience: 27 Degrees: B.A. Interdisciplinary Science, Psychology, B.A., Educational Leadership, MEd; Other notables: Base Pair Lead Teacher; University of Mississippi Medical Center Kaplan Tutor; MS Academy of Sciences Teacher of the Year; Mississippi Science Teachers Association Teacher of the Year; Mississippi Star Teacher, Multiple MJSHS awards, CDC Science Ambassador
Teacher E	Subjects taught: AP Biology, Biomedical Research Interventions, Chemistry Years experience: 34 Degrees: B.S., M.S., Ph.D. Science Education/Biology Other notables: 2013 Presidential Award for Excellence in Mathematics and Science Teaching - Mississippi, Science
Teacher F	Subjects taught: Biology I and II, Biomedical Research, Dual Enrollment Human Anatomy and Physiology I and II Years experience: 24 Degrees: B.S.E. Biology and Chemistry Education, M.S. Natural Science Other notables: National Association of Biology Teachers Outstanding Biology Teacher Award; Lockheed Martin Science Olympiad National Coaching Excellence Award

Table 2.**STEMI Teacher Domains and Competencies**

Domain: ATTITUDES TOWARD FLIPPED LEARNING & TEACHING in STEM <i>Demonstrates willingness to engage in efforts to effectively teach STEM in a flipped learning environment</i>	
1. Confident in teaching capability	
2. Confident in teaching STEM content	
3. Willing to design and implement innovative STEM curricula	
4. Willing to actively participate in a community of learners about flipped learning in STEM	
5. Willing to receive feedback on flipped learning STEM teaching	
6. Willing to improve STEM concept knowledge	
Domain: KNOWLEDGE APPLICATION <i>Applies knowledge of flipped learning, health content, and best practices in teaching to develop lessons that are aligned to standards and represent a coherent sequence of learning</i>	
1. Writes and aligns learning objectives and outcomes for flipped lessons and in-class lessons	
2. Creates lesson plans and content to meet learning objectives	
3. Incorporates hands on and/or inquiry-based STEM activities to complement and extend material outside class	
4. Utilizes new techniques in daily routines to replace old techniques, not merely use them as additional techniques	
Domain: INSTRUCTIONAL PROFESSIONALISM <i>Implements, evaluates, and disseminates flipped learning STEM instruction</i>	
1. Implements a flipped learning instructional method	
2. Monitors the effectiveness of instructional practices	
3. Demonstrates to other teachers the effectiveness of flipped lesson instruction	
4. Identifies and applies for support for flipped learning STEM teaching/programs/students	
5. Engages in evaluation activities as a practitioner-scientist	
Domain: LEARNING ENVIRONMENT MANAGEMENT <i>Implements effective pedagogical practices to support active learning in a flipped learning environment</i>	
1. Implements classroom management practices that facilitate a positive and productive learning environment	
2. Connects learning with students' previous knowledge and experience, highlighting the value of an assigned activity in personally relevant ways	
3. Models technology to facilitate students' success with the technology in the flipped environment	
Domain: TECHNOLOGY SKILLS <i>Utilizes technology to effectively engage in flipped learning instructional methods</i>	
1. Utilizes Online Learning Management systems (i.e., Canvas, Blackboard)	
2. Utilizes digital assessment tools	
3. Captures and edits images, audio, and video to engage students	
4. Utilizes multimedia in instruction	
Domain: CONTENT KNOWLEDGE - HEALTH <i>Demonstrates knowledge of health-related content</i>	
1. Health data related to obesity and associated chronic diseases, health harms	
2. Health literacy, general	
3. Anatomy and physiology related to obesity and associated chronic diseases and health harms	
4. Causes of obesity	
5. Consequences of obesity	

Table 3.

Competencies and Assessments

ATTITUDES TOWARD FLIPPED LEARNING & TEACHING in STEM <i>Demonstrates willingness to engage in efforts to effectively teach STEM in a flipped learning environment.</i>				
Code	Competency	Novice	Intermediate	Advanced
AT-1	Confident in teaching capability	Teaching Self-Efficacy Scale -Total score: 24–96	Teaching Self-Efficacy Scale - Total score: 97–168	Teaching Self-Efficacy Scale -Total score: 169–216
AT-2	Confident in teaching STEM content	STEBI - Personal Science Teaching Efficacy scale score: 0–39	STEBI - Personal Science Teaching Efficacy scale score: 40–51	STEBI - Personal Science Teaching Efficacy scale score: 52–65
AT-3	Willing to design and implement innovative STEM curricula	Interested in innovative STEM curricula	Participates in designing innovative curricula or implements innovative curricula	Leads developing of innovative curricula and implements innovative curricula
AT-4	Willing to actively participate in a community of learners about flipped learning (FL) in STEM	Observes, attends, responds to community	Actively participates in community interactions	Initiates and leads interactions
AT-5	Willing to receive feedback on FL STEM teaching	Receives feedback, may not incorporate feedback or does not have a positive attitude about feedback	Positively receives feedback and incorporates feedback to improve teaching	Actively seeks feedback, receives feedback positively, and incorporates feedback to improve teaching
AT-6	Willing to improve STEM concept knowledge	Participates in required professional development opportunities	-Discusses STEM content with colleagues -Seeks out professional development -Accesses and engages scientific literature	-Gains additional degree/certification in content area -Leads professional development in content area
KNOWLEDGE APPLICATION <i>Applies knowledge of flipped learning, health content, and best practices in teaching to develop lessons that are aligned to standards and represent a coherent sequence of learning.</i>				
Code	Competency	Novice	Intermediate	Advanced
KA-1	Writes and aligns learning objectives and outcomes for flipped lessons and in-class lessons	-Learning objective(s) not clear and not measurable -Prior-to-class work and in-class work is not aligned	-Learning objective(s) not clear or not measurable -Prior-to-class work/in-class work demonstrate some alignment	-Objective statement s) clear and measurable -Prior-to-class work and in-class work are well aligned
KA-2	Creates lesson plans and content to meet learning objectives	-Lesson plans are developed but do not clearly connect to learning objectives -Course content developed but does not clearly connect to learning objectives	-Lesson plans and content connect to learning objectives -All learning objectives have readings/other assignments -All learning objectives have related class activities	-Assigned readings, activities are of appropriate length and depth for student attention in meeting all learning objectives -Encourages activities, discussions for demonstration of met learning objectives
KA-3	Incorporates hands on and/or inquiry-based STEM activities to complement and extend material outside class	-Conducts minimal hands on/inquiry-based activities in class -No connection of material beyond classroom	-Substantial hands on/inquire-based activities in class -Class activities connect to homework/out of class activities -Students participate in related field trips or out of class events	-Instructor develops connections to offer experiences for students to engage in STEM outside of class (i.e., science fair, lab placements) -Instructor builds connections to offer multiple avenues of exploration for students to consider college majors and careers in STEM
KA-4	Utilizes new techniques in daily routines to replace old techniques, not merely use them as additional techniques	-Incorporates minimal additions to pedagogical techniques	-Adds new pedagogical techniques and begins to replace some old techniques	-Completely adopts new pedagogical techniques as appropriate

INSTRUCTIONAL PROFESSIONALISM <i>Implements, evaluates, and disseminates flipped learning STEM instruction.</i>				
Code	Competency	Novice	Intermediate	Advanced
KIED-1	Implements a flipped learning instructional method	-Assigns for homework readings and minimal assignments (ex. Worksheet) to introduce lesson before class. Class: >50% Lecture	-Assigns homework that introduces lesson through readings, assignments, videos. Class: <50% Lecture -A moderate amount of active learning in the classroom based on out of class assignments	-Fully inverted course. Nearly all content provided in homework/ before class. Options to ask questions and discuss difficult material briefly in class. -Mostly active learning in the classroom based on out of class assignments -Supports students in class in searches for answers and solutions to problems based on student learning before class
KIED-2	Monitors the effectiveness of instructional practices	-Does not use formative assessment techniques	-Incorporates formative assessment -Adapts practice minimally	-Formative assessment is fully integrated into course and instructional practice is continually adjusted to improve effectiveness
KIED-3	Demonstrates to other teachers the effectiveness of flipped lesson instruction	Discusses FL with other teachers	Demonstrates and mentors others to utilize FL	Presents at conferences, publishes on methods
KIED-4	Identifies and applies for support for FL STEM teaching/programs/ students	Only seeks support from school district	Participates in funding requests, but does not initiate/ submit on own	Initiates funding requests and submits grants as lead
KIED-5	Engages in evaluation activities as a practitioner-scientist	-Will implement evaluation/assessment as requested by others	-Identifies opportunities for evaluation, seeks assessment tools/method to formally evaluate practice	-Engages in formal evaluation of practice -Participates in presentation and publication of data
LEARNING ENVIRONMENT MANAGEMENT <i>Implements effective pedagogical practices to support active learning in a flipped learning environment.</i>				
Code	Competency	Novice	Intermediate	Advanced
LEM-1	Implements classroom management practices that facilitate a positive and productive learning environment	-Recognizes the need for different classroom management techniques when using FL but does not yet change any practices	-Creates physical environment that promotes student engagement in flipped learning as evidenced by students working on task	-Actively engages in encouragement and supports group interactions to facilitate collaborative learning
LEM-2	Connects learning with students' previous knowledge and experience, highlighting the value of an assigned activity in personally relevant ways	-Explains relevance of material	-Discusses relation of material to prior topics -Helps students draw connections from the topic to prior experiences and future goals	-Facilitates activities and discussions to encourage students to make their own connections to the material -Provides hands on experience for students to connect with course material
LEM-3	Models technology to facilitate students' success with the technology in the flipped environment	-Is able to utilize technology	-Demonstrates technology to students	-Incorporates modeling and other techniques that result in effective student use of tech
TECHNOLOGY SKILLS <i>Utilizes technology to effectively engage in flipped learning instructional methods.</i>				
Code	Competency	Novice	Intermediate	Advanced
TS-1	Utilizes Online Learning Management (OLM) systems (i.e. Canvas, Blackboard)	-Posts syllabus/lesson plan and assignments -Uses management system to disseminate information in text form	-Utilizes multimedia capability of OLM system -Tracks student activity in OLM	-Uses OLM system as platform for student interaction -Creates step by step lessons for students to engage in material before class
TS-2	Utilizes digital assessment tools	-Accepts assignments submitted through online learning management	-Creates and posts assessments through online learning management system	-Designs step by step lessons and activities with built in questions and comments to help students learn

		system -Posts grades	-Uses system to post individual feedback	from mistakes (adaptive course materials)
TS-3	Captures and edits images, audio, and video to engage students	-Uses existing multimedia (Youtube, TEEd, etc) to introduce lesson and motivate students -Uses videos of instructing elements of lesson	-Incorporates multimedia into own lectures to demonstrate examples in class or for homework	-Creates and incorporates original multimedia -Allows for stopping, starting, and re-watching whenever students desire
TS-4	Utilizes multimedia in instruction	-Use multimedia to reinforce material -Use of projector and PowerPoint	-Uses multiple forms of presentation/lecture delivery (Powerpoint, Prezi, etc) -Posts lectures online of narration over Powerpoint lessons or similar version without video	-Creates video lectures of appropriate length and includes examples -Uses multimedia to bring info/ experiences to students without leaving school -i.e., video conferencing with scientists, videos of lab activities not possible in high school -Instructor incorporates hands-on activities for students to work with multiple forms of technology
CONTENT KNOWLEDGE - HEALTH <i>Demonstrates knowledge of health-related content.</i>				
Code	Competency	Novice	Intermediate	Advanced
H-1	Health data	-Minimal use of health data in instruction	-Able to identify data and present data related to topic -Able to utilize data to engage students in deeper thinking about topic	-Challenges students to think about limitations of data -Supports original data collection efforts
H-2	Health literacy	Health Literacy Skills Instrument- Total score: <70	Health Literacy Skills Instrument- Total score: 70–81	Health Literacy Skills Instrument- Total score: >82
H-3	Causes and consequences of obesity	-Aware of but cannot describe etiology and health consequences of obesity	-Can describe etiology and describe health consequences of obesity	-Can integrate knowledge of etiology and health consequences into science subject area (e.g., biology, chemistry)