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Teaching Science Content Area Literacy to 21st Century Learners

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Abstract**—**The use of new literacies within science classrooms needs to be balanced by teachers to both teach different forms of communication while assessing content area proficiency. Using new literacies such as Twitter and Facebook needs to be incorporated into science content area literacy studies in addition to continuing to use generally-accepted forms of scientific content area presentation which include scientific papers and textbooks. The research question this literature review seeks to answer is "What are some ways in which new forms of literacy are better suited to teach scientific content area literacy to 21st century learners?" The research question is addressed through a literature review that highlights methods currently being used to educate the next wave of learners in the world of science content area literacy. Both temporal discourse analysis (TDA) and critical discourse analysis (CDA) were used to determine the need to use new literacies to teach science content area literacy. Increased use of digital technologies and a change in science content area pedagogy were explored.

Keywords**—**Science content area literacy, new literacies, critical discourse analysis, temporal discourse analysis.

I. Introduction

THE need for integration of new forms of literacy has been a constant point of contention within content area studies. While initiatives such as the Common Core Standards [1] focus on "align[ing standards] with college and career expectations," the battle to incorporate new forms of literacy into scientific content areas still ensues. Teachers of various science content areas have the daunting task of balancing the use of new forms of literacy in the classrooms with exposing students to generally-accepted forms of scientific communication such as scholarly papers and textbooks. To better equip students with the tools needed to make personal or global decisions about science content and practices, teachers must learn how to present the content in new ways. As stated by Mishra and Koehler [2], "New forms of literacy are not often integrated due to teacher limitations." However, not exposing students to other forms of literacy can leave them at a disadvantage in terms of future college and career success and learning higher-order thinking skills. Initiatives examined in this paper are increased use of digital technology and software and a change in science content area teaching pedagogy.

A. Research Question

Despite the hindrances of teacher limitations and balancing new curriculum standards with traditional methods of teaching, schools and educators are seeking and employing new ways to teach science content area literacy. This paper seeks to answer the question "What are some of the ways in which new forms of literacy are better suited to teach science content area literacy to 21st century learners?" Specifically, this paper will examine in what ways modern and/or non-conventional ways of teaching science literacy can still aid students in becoming part of the scientific community.

II. Methodology

The research question is addressed by highlighting methods currently being used to educate the next wave of learners in the world of science literacy. For this study, research articles focusing on teaching science content area literacy in the United States (US) will be analyzed. No work will have been written earlier than 2000 in order to highlight more recent methods of developing content area literacy. Only papers or books that discuss developing scientific content area literacy in middle and high school students will be examined. The majority of articles were found using Google Scholar. Key terms such as 21st century learners/learning, new literacies, science context area literacy, content knowledge, and online science games were terms used to find relevant references. The same terms were used within a search within Google to find the rest of the documentation. While numerous articles were found, only sources that supported the research question were used. CDA and TDA were used to frame the need for using new literacies to teach science content area literacy and guided which references were chosen to support this claim.

CDA was employed in this literature review as educating new STEM teachers on better ways to equip students is a matter of justice. CDA allows researchers to study the effect language has on social practices and problems [3]. An applied use of CDA is to determine to what extent inequality is resisted, asserted, and sustained through the use of text and talk [4]. Researchers who use CDA are interested in investigating the naturally-occurring language of their target population [5]. This includes the use of non-verbal interactions and the context of language use [5]. CDA gives researchers the opportunity to examine a phenomenon from an interdisciplinary yet problem-oriented manner [5]. The use of CDA allows for the examination of methods 21st century learners interact with STEM content to develop content area literacy. Specifically, CDA can help determine if students are able to learn the necessary content area literacy to assimilate themselves into the STEM community.

TDA was chosen as content area literacy is developed over time. As Barnes [6] stated, "Most learning does not happen

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suddenly: we do not one moment fail to understand something and the next moment grasp it entirely." As such, students are exposed to information in various ways in attempts to introduce students to the concepts important for a given discipline [7]. In terms of growing science content area literacy, students acquire more skills and terms over time. As a student progresses in his/ her studies, the language used also becomes more complex and dependent on information gained in earlier courses.

A. Theoretical Framework

A few different theories frame this paper. The first is Piaget's theory of cognitive development, primarily how knowledge can be acquired, constructed, and used in a specific content area. In this theory, Piaget [8] asserted that language is dependent on knowledge and understanding gained through biological maturation and environmental experiences. To accompany this theory is situated cognition theory [9]. This theoretical perspective acknowledges knowing "is situated, being in part a product of the activity, content, and culture in which it is developed and used" [9]. As noted by Mishra & Kohler [2], situated cognition is founded on the notion "learning is best supported when the content is part of a context that the students can perceive as meaningful, assign value to the subject matter, and develop an understanding of the relation of it with their lives." The last theory supporting this paper is Rosenblatt's transactional theory. Rosenblatt [10] claimed that reading is a transaction between the reader and the writer. The response is what the reader takes away from the text and the reader's reaction to the text determines what knowledge is learned [10]. While not a theory, a guideline used in exploring effective content area literacy techniques is that of Common Core standards. Specifically, Common Core [1] standards that require the teaching of transferrable skills and practice with complex texts and academic language guided the content area literacy practices discussed.

B. Definitions

In order to gain a common understanding, key terminology will need to be defined.

21st Century Learners: are defined as: ... students [that] master content while producing, synthesizing, and evaluating information from a wide variety of subjects and sources with an understanding of and respect for diverse cultures. Students demonstrate the three Rs, but also the three Cs: creativity, communication, and collaboration. They demonstrate digital literacy as well as civic responsibility [11].

Content knowledge (CK): is knowledge about the actual subject matter that is to be learned or taught [2].

Discourse: as defined by Gee [12] is "an association of socially accepted ways of using language, other symbolic expressions and artifacts of thinking, feeling, believing, valuing, and acting that can be used to identify yourself as a member of a socially meaningful group." The "socially meaningful group" is the scientific community.

New Literacies: "focus on ways in which meaning-making practices are evolving under contemporary conditions, but are in no way limited to, technological changes associated with the rise and proliferation of digital electronics" [13].

Pedagogical content knowledge (PCK): can be defined as "the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organized, adapted, and represented for instruction" [2].

Pedagogical knowledge (PK): is "deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims" [2].

Scientific literacy: as defined by the National Science Education Standards, is "the understanding of science content and scientific practices and the ability to use that knowledge to participate in decision-making that is personal or that affects others in a global community" [14].

Technology knowledge (TK): is "knowledge about standard technologies, such as books, chalk and blackboard, and more advanced technologies, such as the Internet and digital video. This involves the skills required to operate particular technologies" [2].

III. Literature Review

A. 21st Century Skills

Methods to grow 21st century learners are driven by the need to develop skills needed to succeed in a global and interactive society. The Partnership for 21st Century Skills (P21) outlines four different student outcomes identified as being vital for today's learners. These include critical thinking, communication, collaboration, and problem solving in addition to knowledge tied to core subjects [15]. Under the umbrella of critical thinking and problem solving, students should learn how to make judgements and decisions through the analysis of evidence, arguments/viewpoints of all sides of an issue, and reflect critically on their own learning [15]. Students should also be able to determine how individual pieces of a whole work together in complex systems [15]. To develop communication skills, students need to be able to use multiple types of media and technologies to communicate with a wide variety of people [15]. Students should also be able to share their thoughts through written, oral, and nonverbal methods while listening to others to determine meaning [15]. Lastly, collaboration is fostered through demonstrated ability to work in teams, valuing contributions made by each team members, and working towards a common goal [15].

B. 21st Century Learners, New Literacies, and Discourse Analysis

The 21st century learners grew from the rise of the Digital Age. Because of this, students in the 21st century are natives of a digital environment [16]. They use social networking to converse and collaborate with others [16]. Most have computers, smartphones, and other types of technology readily at their fingertips [16]. However, in typical classrooms, students work individually using paper and a writing utensil which is a far departure from their preferred communication methods [16]. This type of passive teaching/learning technique causes students to not learn the material [17].

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As Figueroa-Flores [18] noted, 21st century learners need increased engagement to grow internal motivation. Utilizing new literacies is one way to do this. Knobel and Lankshear [13] stated that new literacies "focus on ways in which meaning-making practices are evolving under contemporary conditions." Examples of new literacies include search engines, e-mail, blogs, podcasts, webpages, wikis, and YouTube [19]. New literacies tend to have four common elements that guide their use:

1) The Internet and other [information and communication technologies] require new social practices, skills, strategies, and dispositions for their effective use.
2) New literacies are central to full civic, economic, and personal participation in a global community.
3) New literacies rapidly change as defining technologies change.
4) New literacies are multiple, multimodal, and multifaceted [19].

Because of the common goals and aspects of new literacies, analyzing their use through a discourse analysis lens is a natural fit. New literacies tie to CDA through Element 2, "New literacies are central to full civic, economic, and personal participation in a global community" [19]. The development of civic and personal involvement leans to increased social justice. New literacies also link TDA to Element 3, "New literacies rapidly change as defining technologies change" [19]. Technology changes over time, requiring an increased level of literacy skill across a student's career.

C. Content Knowledge and Teaching Strategy

Before examining other methods to teach content area literacy, it is vital to understand various shifts in teaching practice and strategy. McDairmid [2] noted that teacher education programs were honed-in on teaching pedagogically-sound classroom practices void of subject matter considerations. To combat this, Shulman [2] introduced the idea of teaching pedagogical content knowledge or PCK. Shulman [2] advocated for PCK with the belief teachers would need to embrace "the aspects of content most germane to its teachability" by tackling both content and pedagogy issues. Simply put, PCK enables teachers to interpret the subject matter in order to find new ways to make it understandable for learners [2].

Numerous authors have written specifically about difficulties appealing to science students while teaching content area literacy. Lijnse [20] discussed a "principle of charity" which is the notion effective teaching is dependent on the teacher's understanding of student's language concerning the subject area. In science, this means the language used when learning about science makes sense to them and serves as "necessary starting place for communicating about science" [20]. However, this is where the dichotomy lies. While teachers agree that the science curriculum needs to be conveyed in ways that are meaningful to each student, they feel powerless to change the curriculum [20]. Pushes to prepare students for exams and standardized testing often limit the amount of time teachers can prepare lessons using non-standard content area teaching methods [20]. While teachers may strongly believe in using alternate methods to teach content area literacy, they can be torn when attempting to insert these methods in the classroom [20]. Tensions within teachers arise when they attempt to use alternate methods to teach content area literacy as they wonder if the content is being transmitted in an efficient and understandable way [20].

Alternatively, some educators' backgrounds beliefs concerning the scientific body of knowledge can be the largest barrier to using non-standard methods to teach science content area literacy. A rigid view of the scientific method can limit new and innovative way to convey the same information [21]-[23]. Brickhouse [21] found that this was mostly true in teachers with a less contemporary view of teaching content area literacy. Hashweh [24] delved further into this phenomenon by examining the educational psychology beliefs of teachers in the field. The differences in teacher beliefs had a direct impact on the actions taken in the classroom [24]. Teachers that subscribed to a learning and knowledge empiricist view did not take into account students' prior knowledge but "emphasized the scientific method both as a paradigm for scientists and for instruction" [20]. Teachers whose foundations was in learning and knowledge constructivist theories recognized students' prior knowledge and sought numerous and varied ways to "promote the construction of conceptual understandings" [20].

In general, Flanagan and Jacobsen [25] assert any issues in changing content area teaching techniques can be summarized into four categories: pedagogical issues, concerns about equity, inadequate professional development, and lack of informed leadership. As stated by Mishra and Koehler [2] and Flanagan and Jacobsen [25], pedagogical issues can hinder support for teachers who seek to intertwine innovative ways to teach science content area literacy with scholarly-accepted practices. In terms of equity, all schools do not have the same resources available to its students [25]. When honing in on the use of computers to teach content area literacy, the American Association of School Administrators [25] found inequities in the use of computers to teach students from poor families, minority children, girls, low achievers, students learning to speak English, children who live in rural areas and children with disabilities. As science and digital equipment can be costly, this then can lead to public schools or schools with low socio-economic status to be at a significant disadvantage when seeking cutting-edge methods to teach science content area literacy [25]. A third issue is limited access to appropriate types of ongoing professional development for teachers [25]. Some teachers may lack the Technological Pedagogical Knowledge (TPK) to use particular technologies in the classroom and do not know how to pair technology with their classroom goals [2]. Even for teachers that actively seek to use novel science content area literacy teaching techniques, the necessary training can be either costly or non-existent [25]. In the digital realm, these teachers may not have access to the programs learning in the training courses which leads to a degradation of skills; what is not used is forgotten [25]. A second-order effect of this is teachers are much more skeptical of learning anything outside of what resources are within arms' reach [25]. The last impediment to teaching science content area literacy in new ways is a lack of informed leadership [25]. If administrators do not have the required vision and experience to guide teachers, advancements cannot take place [25]. Unfortunately, this means even schools with the right resources can be using them for less than desired teaching outcomes [25]. One example of this is schools using computer labs solely for typing versus teaching internet research techniques.

D. Content Area Literacy Development Using New Literacies

As discussed by Lesley et al. [26], digital media has become a driving force in current education practices. In addition to increased computer use in every classroom, students are now bombarded with social media such as Facebook and Twitter. With digital media being so readily available, scientists and scientific agencies are now looking for ways to make science more accessible and teachers are seeking ways to effectively teach in these new literacy forms. Twitter features an extensive list of science professionals, professional organizations such as the Nashville Chapter of the American Chemical Society, and teacher resources like Go! Chemistry Videos and Molecular Jig Games [27]. Feeds such as CitSciAssoc exist solely to educate regular citizens about science topics in 140 characters [27]. These organizations, in addition to many others, are attempting to integrate science into young students' learning experiences by appealing to them in their "native language." To further content and electronic media literacy, assignments can be to list the top five science feeds a student found interesting. Teachers can pull up sites like these to use as introductions to various lessons. For instance, for a lesson on chemistry, a chemistry video could be shown illustrating the type of chemical reaction being taught in class. Both in-class practice and student research on electronic media sites will allow students to learn not only more about a particular field of science, but also how to use new sources of media for research purposes.

Computer programs can also have a long-lasting and valued impact on young scientific learners. Programs such as Alien Contact! were designed as an aid to teach math, language arts, and scientific literacy skills to middle and high school-aged students [28]. Designed by Dunleavy et al. [28] in collaboration with MIT and the University of Wisconsin at Madison, students can navigate a virtual world that is overlaid on a real space. Interactive video, audio, and text files in the specially-designed GPS and handheld computer programs are triggered when students come within thirty feet of a "digital artifact" [28]. Through student interactions with aliens that have landed on Earth, students can learn how to collect evidence that can be pieced together to determine why the aliens landed [28]. These interactions teach the scientific process and language in addition to allowing students to practice higher-level orders of thinking [28]. Open game play that gives students options on types and frequency of interactions paired with multiple entry points for teachers to build other iterations appeals to both teachers and students. Giving students an option on how to interact with the aliens and where they should explore keeps them interested while meeting Massachusetts State Science Standards [28].

Dunleavy et al. [28] spent a year collecting observations and interviews from the eighty middle and high school students and six teachers who took part in the study. The study found students of all socio-economic backgrounds enjoyed learning not only how to use the technology, but also the subject area requirements [28]. While in its current state large-scale implementation may be difficult, future iterations of the game may allow teachers to use the four roles (chemist, cryptologist, computer hacker, and FBI agent) available to students to "accommodate, leverage, remediate, or reinforce various skills sets of individual students" [28].

Shulman [2] also highlighted the transformative nature of technology in the classroom. Modern interactive multimedia simulations in addition to use of digital whiteboards, the internet, and other such applications can appeal to students' interests while making the information "accessible and comprehensible" [2]. One such example is the use of CHIME, an online program/plug-in that can display, rotate, and reformat 2D and 3D molecules. This tool allows learners to relate to the molecules by giving them the opportunity to see and manipulate them [2]. Using tools such as CHIME or the numerous virtual labs available to students aids them in making sense of models, diagrams, simulations and graphs, all of which are vital parts of scientific literacy [14]. The use of these types of programs can be powerful if incorporated in a meaningful way that furthers course goals and teacher pedagogical practices. As Mishra and Koehler [2] point out, pedagogy directly impacts the tools available to students and how they are implemented in the classroom.

E. Content Area Literacy and Pedagogies

A second way to grow content area literacy is to change the pedagogy used in the classroom. While science classrooms may bring memories of one-sided lectures, a shift from teacher-centered to student-centered learning can be seen throughout US classrooms. One example of this is Jake, a veteran high school science teacher. In his classroom, he spends ample time creating opportunities to teach authentic problems, science ideas, student and teacher collaboration [20]. He also invites two-way dialog that "promotes thinking, questioning, and extension" [20]. This type of teaching requires higher levels of pedagogical and content knowledge but ultimately allows for students to gain critical content area literacy in ways meaningful to the student [20]. A change from teacher-centered to student-centered learning also permits teachers to link knowing science to doing science [20]. Learning by discovery is part of the authentic scientific experience "in which practices and scientific ideas are not separable understandings, but rather interconnected and mutually supportive strands of science literacy" [20]. Additionally, authentic experiences give students opportunities to tap into their prior knowledge base by creating opportunities to learn through experiences with familiar objects [14]. These authentic scientific experiences allow students to apply what they learned on a global level, a key part of science literacy [14].

Another change in pedagogy is teaching science content area literacy along with other content areas. One trend among

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teachers is to integrate language arts literacy with science [20]. Combining literature with science not only "humanizes science in the eyes of children and parents" while challenging the stereotype science is "a sterile, noncreative subject that is unrelated to the arts" [29]. Science inquiry can be tied to using a wide range of writing styles that includes creative stories, journals, and observations [20]. These alternative forms of writing still allow for scientific discussion and discourse to occur among students and teachers, a staple of inquiry learning. One specific type of writing that can be used in scientific settings is the multigenre essay. Multigenre essays combine various expressive styles such as essays, poems, and drawings to convey a unified message [30]. While atypical of scientific writings, multigenre essays can teach the same content area facts and vocabulary in a way that is more accessible to learners. Students can also convey their findings, whether it be experimental results or a recap of a book chapter or module, in a way that is meaningful to them. Multigenre essays, like other narrative works, may assist students in "constructing explanations and arguments, which are essential components of scientific discourse" [14]. These personal expressions allow teachers to see what learning has occurred, what misconceptions need to be addressed, and what concerns the student may have. Other content literacy advocates like Lesley et al. [26] advocate that writing of any type can help prepare students for future success both in and outside of their studies in a given area. Considering most students will not go on to pursue careers in science, teachers can teach science content literacy while supporting them in reading, writing, and communication skills [14].

Changing content area teacher pedagogy to make them believe they are responsible for teaching reading comprehension, at least in their content area, will provide students with future academic success in other subject areas. The National Reading Panel (NRP) [31] drafted eight reading strategies based on research conducted. Five of the strategies, cooperative learning, story structure, question generation, summarization, and multiple strategy instruction, are better suited to be taught through non-standard scientific writing styles. Story structure teaches students to ask and answer who, what, where, when and why questions about a given passage [32]. Question generation asks these questions plus "What will happen?" [32]. Teachers can employ these two tactics in classrooms by asking their students to write news-type stories about a scientific article. Summarization, or having the reader write the main ideas of a work and then tying them into one coherent paper, can take on the form of poems, stories, or drawings [32]. Multiple strategy instruction and cooperative learning best teach comprehension by allowing students to learn from each other and the teacher is flexible and differing interactions [32]. Sadly, most teachers observed in a study conducted by Ness [32] did not feel qualified nor responsible for teaching comprehension. As a result, only 3%, or 82 minutes, of classroom time in four middle school and four high school classes was observed. However, the same teachers could not deny comprehension is beneficial for students of all levels. Alternate forms of writing lean toward growing students' reading comprehension while showcasing their scientific knowledge in easy-to-understand ways.

IV. Findings

The teachers can employ new and existing technologies such as Twitter, Facebook, virtual labs, and science-based computer programs to expose students to scientific concepts. These technologies can also relate to students using language and contexts they already understand and can better prepare them to use technology for educational purposes which falls in line with Piaget's theory of cognitive development. Student-centered teaching practices like inquiry learning give students opportunities to discover science in ways meaningful to them, links knowing science to doing science and allows for student-teacher and student-student collaboration. Student-centered learning also provides authentic science opportunities, gives students opportunities to access prior knowledge to reinforce learned facts, and creates global learners. Both of these aspects tie to situated cognition theory. Lastly, combining science content area teaching with other subjects can create close ties between multiple subject areas while promoting writing in easy-to-understand ways. Students can learn the practices and vocabulary needed to identify with the scientific community using any of the above-mentioned methods as long as there is an emphasis on teaching and learning accurate science. This interaction between students writing and others reading their work is part of Rosenblatt's transactional theory [10]. Exercising the use of new literacies to teach science content area literacy supports Common Core standards across the K-12 curriculum.

While there are clear methods to update science content area teachings, there are issues to wide-spread implementation. First, adding various forms of technology to the classroom may not be feasible due to budget limitations. Additionally, teachers must have the pre-requisite TK to employ the chosen technology [2]. The goal is to not only mimic the scientific knowledge the teacher wishes to convey but also the technical knowledge needed to succeed in future academic and scientific endeavors. To use student-centered learning and paired teaching techniques, teachers must have deep PK in order to shift their practices [2]. This shift may result in more time taken to both draft and implement teaching plans. The teacher will also need enough content knowledge to be able to explain the science concepts and vocabulary in novel ways [2]. Teaching science with another content area may require two or more teachers to work together to create joint lesson plans. Fig. 1 summarizes these findings.

In terms of CDA, employing new literacies to further science content area literacy is part of social justice. The internet is a vital part of classrooms in developed areas [19]. However, as previously stated, schools in low socio-economic communities may not have equal access to digital resources [19]. Because of this, developing science content area literacy across a global community may not be even due to a lack of resources [19]. As Yang et al. [32] found, this disparity between urban and rural areas is the most prominent factor in education inequality. Without equal opportunities to learn science content area

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literacy, future scientists may predominantly come from areas with advanced technologies while discouraging students from more disadvantaged areas. Programs such as Thailand's "One Tablet PC per Child" attempted to close the technological gap but still struggled based on poor internet connection and infrastructure [34]. The United Nations even attempted to address this growing divide through the coordination of efforts that try to grow the capacity for universal education opportunities [33]. While technology implementation may be difficult for K-12 teachers, new literacies implementation has been credited with assisting with language scaffolding and support for independent reading and writing [35].

Method	Example(s)	Benefit(s)	Issue to implementation	Reference
Digital Media	Twitter	Teaches students how to use existing technology for scientific purposes	Potential lack of computers in the classroom and/or at home	[26}
	Facebook	Appeals to students in their "native language"	Teacher must have appropriate technical knowledge (TK)	[2]
Computer programs/software	CHIME	Uses games to teach science	Potential lack of computers in the classroom and/or at home	[28]
	Alien Contact!	Can pair science with other content areas (math, language arts, etc)	Programs/add-ons may be costly	[2]
	Virtual labs	Can safely teach science skills (i.e. labs can be conducted without incident)		[14]
	Whiteboards	Teaches how to use new forms of media for educational purposes	Teacher must have appropriate technical knowledge (TK)	[2]
		Allows students to easily see what may not been seen/experienced by the naked eye		
Student-centered learning	Inquiry method	Gives students opportunities to discover science in ways meaningful to them	Requires pedigogical change in teaching practices and deep pedigogical knowledge (PK)	[20]
		Links knowing science to doing science		[2]
		Allows student-teacher and student-student collaboration	May take more time to implement in large classrooms	[14]
		Provides authentic/real-world science opportunities	Requires appropriate content knowledge (CK)	[2]
		Gives students opportuniities to access prior knowledge to reinforce learned facts		
		Creates global learners		
Combining content area teaching	Science with language arts	Humanizes science	Requires pedigogical change in teaching practices	[29]
		Creates close ties between science and the arts		[2]
		Promotes writing and discussing science	May require two or more teachers to construct and teach joint lesson plans (time and class size issues)	[30]
		Promotes writing about science in easy to understand and creative ways	May require more time spent teaching/grading to understand and address misconceptions	[14]
		Provides opportunities to practice writing that mimics real-world skills		[26]

Fig. 1 Methods to Develop Scientific Content Area Literacy

TDA also addresses disparities in science content area literacy development. In various areas such as rural China, there is only one teacher available to address all students' needs to include maintaining facilities, cooking, and teaching [33]. Ensuring that teachers in these schools have the qualifications to expertly instruct science content area literacy using new literacies to students over time is difficult and may lead to an atrophy of content area literacy ability [33]. Additionally, efforts to improve the literacy foundation of adolescents has not yielded positive growth in literacy later in life [36]. High school students were found to still struggle to read more advanced texts because of a lack of mastery of reading tools used in early grades [36]. As typical reading skills used in higher levels may not be generalizable, the use of new literacies that students are familiar with may help overcome content area literacy barriers [36].

V. Suggestions for Future Research

Based on the research above, there are many suggestions for teachers and for future research. Teachers should first gauge what resources are available to students both in and out of the classroom. Assigning take-home assignments to students that require internet use when they do not have access could lead to both negative attitudes toward learning and a larger educational divide among students. Instead, teachers should provide the means to complete assignments and activities using classroom resources if necessary so all students can take part in meaningful learning. Second, teachers should look for ways to use students' prior knowledge to grow scientific content area literacy. This includes tapping into knowledge gained from other courses and content areas and working with other teachers for cross-collaboration. Third, teachers should look for ways to assess content area literacy growth using interactions with new literacies. This may mean creating new rubrics that are more inclusive of technology use. Lastly, teachers should also seek ways to assess scientific content area literacy growth over time. Doing so may require the use of portfolios and/or giving the same assessment to students at multiple times in their academic careers.

Many of the suggestions also tie to future research. One future study could look at scientific content area literacy growth over time. Students who use new literacies for content area literacy development would be tracked and progress gauged through standardized and/or peer-vetted assessments. Another study could be focused on scientific content area growth per new literacy. A content area literacy assessment would be given at the beginning and end of a module or teaching block. During the block, students would be given one new literacy such as Twitter or a computer game to use to learn about the content. The results of the assessment would then be compared to determine which new literacies are most effective in growing the desired content area literacy. Yet another study could compare content area literacy growth for students who use new literacies versus those who do not. This study could also include the time students spend using the new literacy to determine if there is a correlation between usage and literacy growth.

VI. Conclusion

The literature review above proves that there are multiple ways the question "What are some of the ways in which new forms of literacy are better suited to teach science content area literacy to 21st century learners?" can be answered. The use of new literacies within K-12 classrooms is critical to the development of content area literacy within students. Posting and reading others' inputs in Twitter or Facebook support Rosenblatt's transactional theory [10]. Computer programs that allow students to interact with an authentic environment is part of situated cognition theory. Moving to student-centered teaching practices to include new literacies work that are sustained over time ties to Piaget's theory of cognitive development. New literacies are a vital part of Common Core curriculum support and development. However, wide-spread use of new literacies for scientific content area literacy development may be limited due to a lack of technology which leads to inequalities in education as analyzed through CDA. Teachers may also not use new literacies for scientific literacy development because of their own lack of development. The inability to advance student skills, such as scientific content area literacy, over time is part of TDA. For new literacies to be effective in growing scientific content area literacy, teachers need to adopt student-centered pedagogical practices.

As stated by Matson and Parsons [37], "Science itself is not static nor should science teaching be unchanging. We need to ensure that teachers are aware of this aspect of science." Krajcik et al. [38] take this further by asserting "Understanding how scientists build, evaluate, and apply scientific knowledge is a core part of this emerging consensus view of scientific literacy." This literacy can be taught using existing and emerging technology paired with atypical methods to teach, read, and write about science. While educators may embrace the ever-changing nature of science, they may be less enthused or able to embrace the changing nature of teaching science quite as easily. This may be for a variety of reasons that include a fear of change and lack of time and support. But as Mishra and Koehler [2] write, "the fact that these technologies are here to stay cannot be doubted."

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