
**Journal of E-Learning and Educational Technologies (JEET)**
Volume.1, Number 1; March-2023;
Published By: Zendo Academic Publishing
https://zapjournals.com/Journals/index.php/jeet
14131 Alder St NW, Andover, Minnesota, USA
zapjournal@gmail.com, editorial@zapjournals.coom

# PREDICTORS OF MORTALITY AMONG COVID-19 PATIENTS IN LUBUMBASHI, DEMOCRATIC REPUBLIC OF CONGO

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**Abstract:** The ongoing pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has claimed millions of lives worldwide. This retrospective cohort study aimed to identify predictors of mortality and evaluate survival among COVID-19 patients in Lubumbashi, Democratic Republic of Congo, from July to September 2021. The study collected data from hospitals in Lubumbashi that take care of COVID-19 patients. The sample consisted of 1276 patients, with 684 males and 592 females. The study found that age above 40, male gender, and diabetes were potential predictors of mortality for COVID-19 patients in Lubumbashi. The survival rate decreased by 20% within 20 days of admission, with the survival rate decreasing to 5% for patients below 40 years of age, 15% for those aged 40-59, and 23% for those aged 60 or above. Male patients had a lower survival rate of 20%, while female patients had a survival rate of approximately 15%. Patients with diabetes had a lower survival rate of approximately 15%. Comorbidities such as hypertension, diabetes, stroke, and respiratory diseases decreased the survival rate among COVID-19 patients. The study highlights the importance of early detection, adequate treatment, and management of comorbidities to improve the survival rate of COVID-19 patients in Lubumbashi.

**Keywords:** COVID-19, predictors of mortality, survival, Lubumbashi, Democratic Republic of Congo, comorbidities.

## 1.INTRODUCTION

In the past two decades, there are been two contemporaneous and intersecting trends in policy regarding K-12 public education in the United States. The first such trend, made a priority in both the Bush ("No Child Left Behind") and Obama ("Race to the Top") administrations, has argued in favor of increased academic rigor in the classroom through the implementation of learning standards, most notably those affecting the areas of English, Math (the Common Core Learning Standards - CCLS) and Science (Next Generation Science Standards - NGSS).

The stated goal of these learning standards initiatives has been to ensure that America's students have the widest possible opportunities to succeed and prosper in the workforce. Here is how the organization responsible for the CCLS has described their efforts:

For years, the academic progress of our nation’s students has been stagnant, and we have lost ground to our international peers. Particularly in subjects such as math, college remediation rates have been high. One root cause has been an uneven patchwork of academic standards that vary from state to state and do not agree on what students should know and be able to do at each grade level….The Common Core is informed by the highest, most effective standards from states across the United States and countries around the world. The standards define the knowledge and skills students should gain throughout their K-12 education in order to graduate high school prepared to succeed in entry-level careers, introductory academic college courses, and workforce training programs [1].

The developers of the Next Generation Science Standards have used similar language to describe their goals and intentions:

Science—and therefore science education—is central to the lives of all Americans, preparing them to be informed citizens in a democracy and knowledgeable consumers. If the nation is to compete and lead in the global economy and if American students are to be able to pursue expanding employment opportunities in science-related fields, all students must have a solid K–12 science education that prepares them for college and careers... Needless to say, major advances have since taken place in the world of science and in our understanding of how students learn science effectively. The time is right to take a fresh look and develop Next Generation Science Standards [2].

The adoption of the CCLS has been controversial and has had a profound effect on teaching and learning in K-12 classrooms, as well as on teacher practice and education, in terms of curriculum development, teacher preparation, and teacher practice [3,4].

At around the same time, there have also been efforts to increase the presence of and need for computer science and computational thinking education widely into K-12 schools in the United States and elsewhere. In the past 10 years, the most vocal efforts towards these goals have come from coalitions of public, private, and corporate entities, such as Code.org, which includes participation from school districts, corporations such as Amazon, Google, and Microsoft, professional organizations such as the International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA), universities, and school districts [5].

The research into the expected and unexpected results of curriculum reform efforts such as CCLS on teacher preparation, teacher practice, and student learning suggest that we be more circumspect about learning standards and their implications. Therefore, this study continued earlier work into the close reading of the New York State Computer Science/Digital Fluency Learning Standards [6], by performing an investigation of the CSTA Computer Science Learning

Standards. The CSTA CS Learning Standards are important as they have been adopted by at least 5 of the 50 United States, and have been influential in the development of CS learning standards in several more.

Therefore, this study performed a close reading of the CSTA Computer Science Learning Standards (CSTA-CSLS) in order to investigate these research questions:

1. What does a close reading of the Computer Science Teachers Association (CSTA) K-12 Learning Standards reveal about the cognitive and epistemic spaces for the teaching and learning of computer science and computational thinking in K-12 schools?
2. What does a close reading of the Computer Science Teachers Association (CSTA) K-12 Learning Standards reveal about the opportunities and challenges for the teaching of computer science and computational thinking to students in grades K-12?

## 2.REVIEW OF THE RELATED LITERATURE –LEARNING STANDARDS AS TEXTS

This study investigated the CSTA Computer Science Learning Standards document using various textual analysis methods and tools which are described under the Methods section below. This section will discuss research relating to the analysis of texts and to the consideration of learning standards documents as texts.

### *2.1.Learning Standards as Texts*

Learning standards documents are unique in that they are human generated writings that have strong regulatory, policy, and legal ramifications and impacts. In a very real sense, they are comprised of lists of requirements for what and sometimes how children in grades K-12 should learn sets of skills and/or content. For example, here is the opening statement announcing the adoption of New York State's Next Generation


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English Language Arts and Mathematics Learning Standards: "The revised New York State Standards aim to reimagine the educational framework for English language arts and mathematics, with the goal of better supporting educators in their instructional practice and to provide additional guidance on achieving a vision of 21st century literacy" [7].

The structure of these documents themselves also direct or suggest how they are read and used.

These documents typically have two major components. The first is a primarily narrative portion (commonly called an executive summary) that tells the "story" of the learning standards contained within outlining "big picture" components, such as the process of creating and adopting the standards, a set of guiding principles shaping the standards, and educational and career goals that will be met by the standards. The second is typically a table that outlines the specifics of the standards (they are legalistic in nature after all), and are often organized by grade level, and topics and subtopics. Additionally, as in the case of the Next Generation Science Standards, these documents can also contain cross-cutting concepts or other high level components.

These standards have two intermingled purposes. First, they are fundamentally requirements documents that outline the scope of instruction in a given content area and grade level. Second, they serve as the foundation for any associated assessments.

Some research has been undertaken which sought to investigate the design and content of such learning standards documents. Some of this research has focused on the alignment between learning standards and the assessments created to measure their impact [8,9,10]. Additionally, some other research has worked to map out the scope of content addressed (or not) in various learning standards documents [11, 12, 13]. Still other research has sought to address the epistemic spaces created by such standards documents [14].

However, little research has been so far conducted that treats learning standards documents as pieces of writing (texts) to be analyzed in the ways we analyzed more common texts in the humanities such as novels, poetry, histories, and plays [15, 16, 17]. Therefore, this study seeks to close that gap by performing a computationally supported exploration of the CSTA CS Learning Standards document.

## 3.METHODS

In order to perform a close reading of the CSTA CS Learning Standards, established techniques and tools that use computational methods for text mining have been employed. Textual analysis is a set of methods within social science and educational research for investigating texts of various kinds [18,19]. We consider a learning standards document to be a unique type of text and thus eligible for this type of analysis. Each of these types of documents has its own structure. The structure of the CSTA CS Learning Standards is depicted in Figure 1. Figure 1 demonstrates that these CS Learning Standards are organized by *grade level*; computer science *concept*; and computer science *practice*.

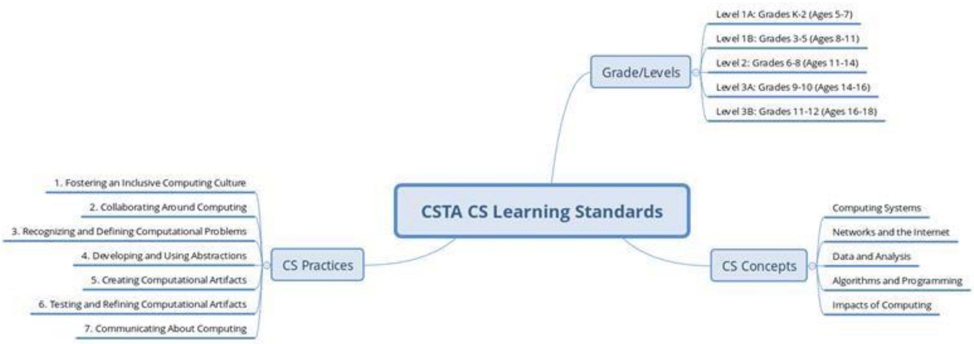


Figure 1. Organization of the CSTA CS learning standards


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To further clarify the structure of this learning standards document, Figure 2 depicts annotated screenshot from the standards document itself, and demonstrates that the learning standards are organized by several parameters: *level and grade* (in this case, Level 2 [which refers to middle school], grades 6-8); computer science *concept* (in this case *computing systems*); and computer science *practice* (in this case, 3.3, which refers to recognizing and defining computational problems).

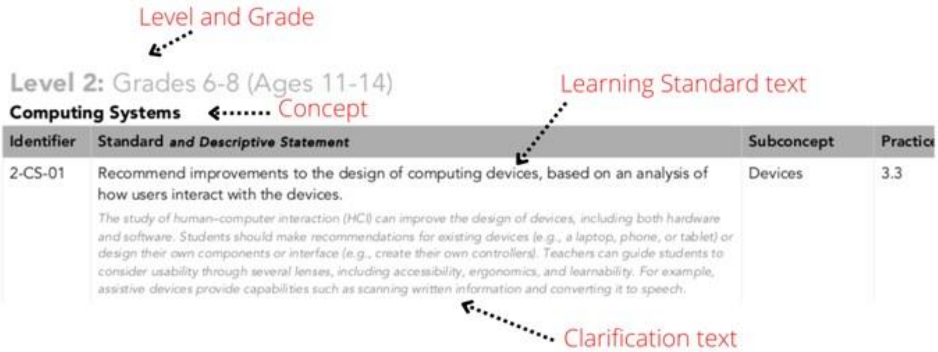


Figure 2. Structure of the CSTA CS learning standards

Social scientists in conjunction with software programmers have created a set of tools for the R programming that were specifically developed to support these types of textual analysis, which are broadly referred to as *tidytext*[20,21]. These computational tools allow for the calculation and visualization of various aspects of a text, including: *word frequencies* (how often a word appears in a text or portion of a text); *relative word frequencies* (word frequencies normalized for the amount of text analyzed); and the *networks of word pairs* in a text or portion of a text). These calculations and visualizations were conducted for the text of the learning standards themselves as well as for the text of the clarifications accompanying each learning standard. Figure 3 depicts the specific analyses and tidytext tools utilized in this study.

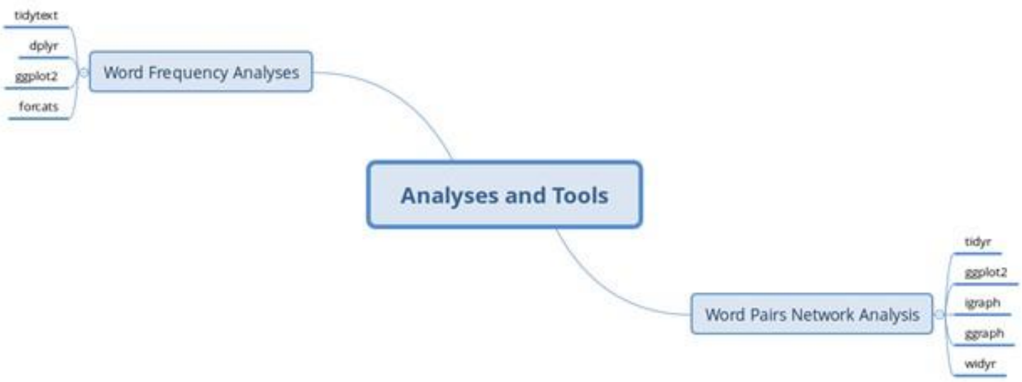


Figure 3. The computational tools for textual analysis utilized in this study

**4.FINDINGS**

In this section, we describe the findings of the various textual and content analyses performed on the CSTA CS Learning Standards document. These findings will address: 1) the distribution of the learning standards by grade level, computer science concept, and computer science practice; 2) analyses of the text used in the learning standards; and 3) analyses of the text used in the *clarifications* associated with each learning standard.

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### *4.1.The Distribution of Learning Standards*

In order to investigate the priorities inherent in this learning standards document, we determined the distribution of the standards along three parameters: grade level, computer science concepts, and computer science practices. These distributions are depicted in Figures 4, 5, and 6, respectively.

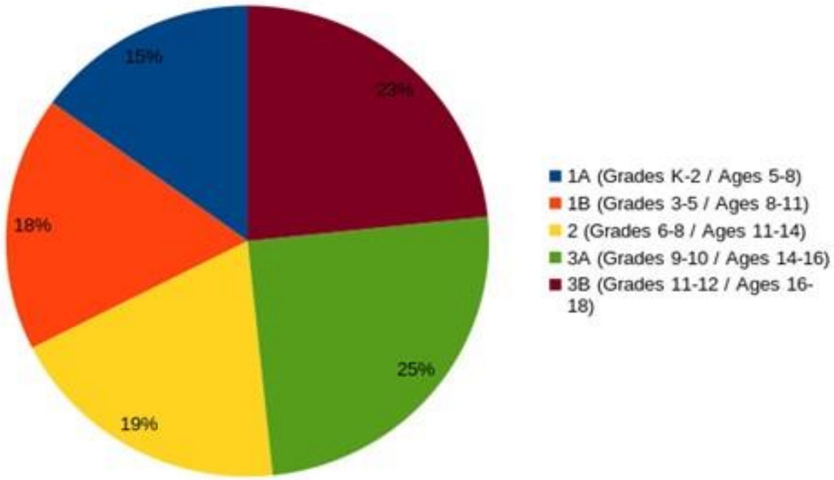


Figure 4. Distribution of CSTA CS Learning Standards by Grade Level

Figure 4 depicts the distribution of these learning standards by grade level. We can see that the majority of the learning standards (67%) are associated with secondary grade levels (grades 6-12; levels 2, 3A, and 3B), with the remainder (33%) are associated with primary grade levels (grades K-5).

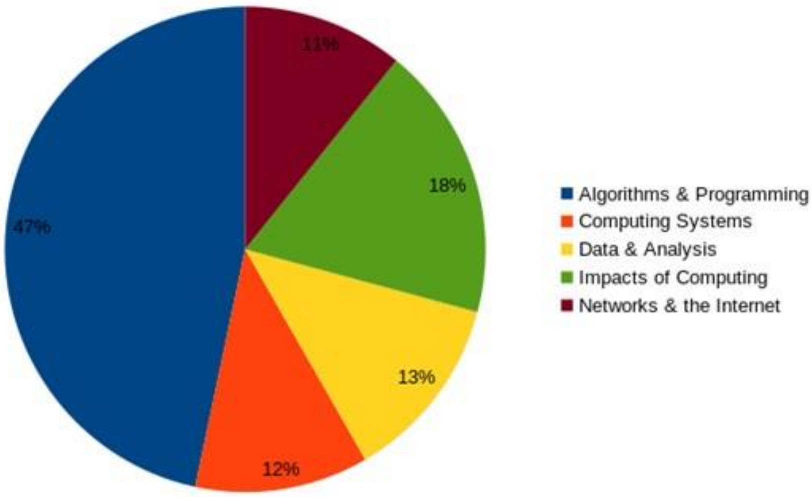


Figure 5. Distribution of CSTA CS Learning Standards by Computer Science Concept

Figure 5 depicts the distribution of learning standards by computer science concept. We can see that the majority of the learning standards (65%) are associated with the two computer science concepts of *algorithms and programming* and *impacts of computing*. The remaining concepts (*data and analysis*, *computing systems*, and *networks and the internet*) are fairly evenly distributed.

Figure 6 depicts the distribution of learning standards by computer science practice

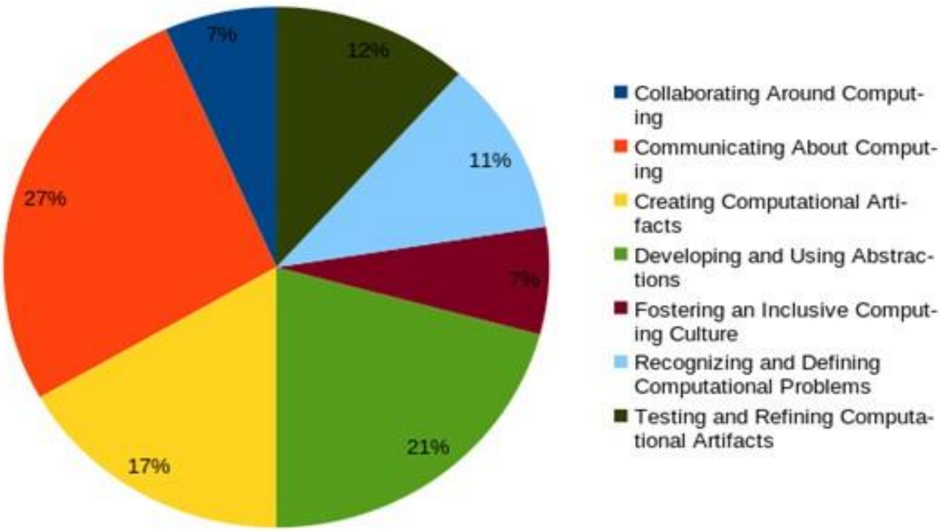


Figure 6. Distribution of CSTA CS Learning Standards by Computer Science Practice

We can see two areas of emphasis in this distribution. The first is related to doing computer science (*developing and using abstraction*s, *creating computational artifacts*, *recognizing and defining computational problems*, and *testing and refining computational artifacts)*. This broad category contains the majority of the standards (60%). The second area of emphasis focuses on communication and collaboration (*communicating about computing*, *fostering an inclusive computing culture*, and *collaborating around computing*, and contains the remaining standards (40%).

***4.2.The Text Used in the Learning Standards***

The text used in the articulation of the learning standards themselves was analyzed in order to investigate word frequencies by *leve*l, *concept*, and *practice*, to explore the networks of word pairs found in these learning standards, and to inquire into the verbs used in these learning standards.

***4.2.1. Learning Standards - Word Frequencies by Level, Concept, and Practice***

The word frequencies used in the text of the learning standards themselves were analyzed and visualized along the dimensions of grade level, computer science concept, and computer science practice. The visualizations of these analyses are depicted in Figures 7, 8, and 9.

Figure 7 shows the visualization of word frequencies for the text of the learning standards along the dimension of level, referring to grade level. In the CSTA Learning Standards document, level 1 corresponds to elementary school, level 2 corresponds to middle school, and level 3 corresponds to high school.

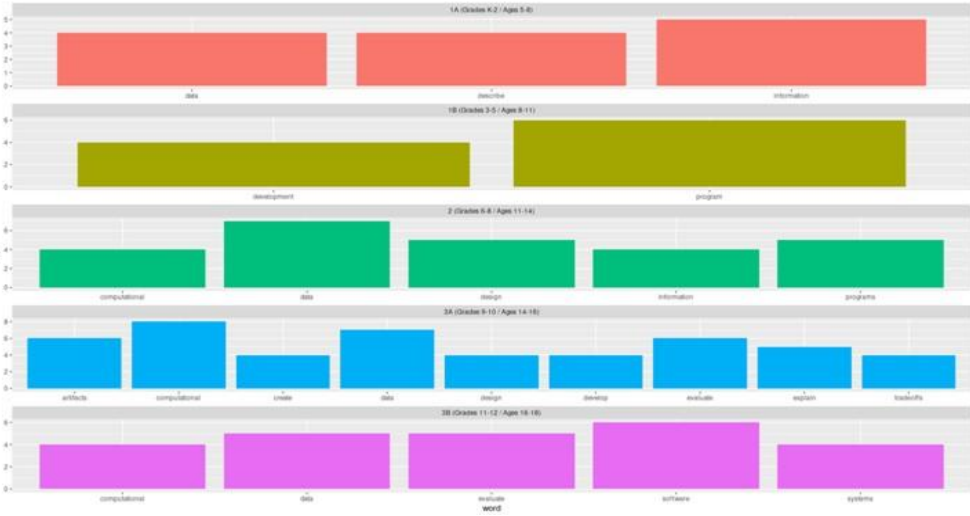

Figure 7. Word Frequencies of CSTA CS Learning Standards by Grade Level

This analysis reveals that the distribution of these word frequencies reflects a larger set of words at the secondary (middle and high school) levels (2, 3A and 3B), and a smaller set at the elementary levels (1A and 1B). At the elementary level, the standards reflect an emphasis on the verb *describe*, along with the nouns*information*, *data*, *program*, and *development*. In contrast, at the secondary level, there is a far wider range of verbs that appear frequently, including: *create*, *design*, *develop*, *evaluate*, and *explain*. This finding is accompanied by a wider range of nouns as well, including: *information*, *programs*, *artifacts*, *tradeoffs*, *software, and systems*.

Figure 8 shows the visualization of word frequencies for the text of the learning standards along the dimension of computer science concept. The concepts of *Algorithms & Programming* and *Computing Systems* reveal the largest ranges of frequently used words, and those of *Data & Analysis* and *Networks & the Internet* revealing the smallest ranges (two for each) of frequently used words. It is word noting Algorithms & Programming is comprised of twenty-one frequently used words.

Figure 8. Word Frequencies of CSTA CS Learning Standards by Computer Science Concept

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Finally, Figure 9 shows the visualization of word frequencies for the text of the learning standards along the dimension of computer science practice. The practices of *Communicating about Computing* and *Developing and Using Abstractions* have the highest numbers of most frequently used words (14 and 13, respectively), and *Recognizing and Defining Computational Problems* has the fewest (1).

Figure 9. Word Frequencies of CSTA CS Learning Standards by Computer Science Practice

#### *4.2.2.Learning Standards - Word Pair Networks*

Bigrams are pairs of contiguous words within a text. The tidytext package allows researchers to analyze and visualize these word pairs. Such an analysis was conducted on the text of these learning standards, and the result of this analysis is depicted in Figure 10.

This visualization reveals a relatively narrow range of word pairs, and these are mostly focused concretely on elements of the learning standards. For example, we see r*efine* → *computational* → *artifacts*, *computing*→ *systems* → *devices*, and *program* → *development*. It is important to note that these sets of bigrams are relatively isolated and do not demonstrate connections between such word networks, and indication of a particular content focus inherent in these learning standards. Lastly, in this visualization, the strength of connections is indicated by the width of the line between word pairs.

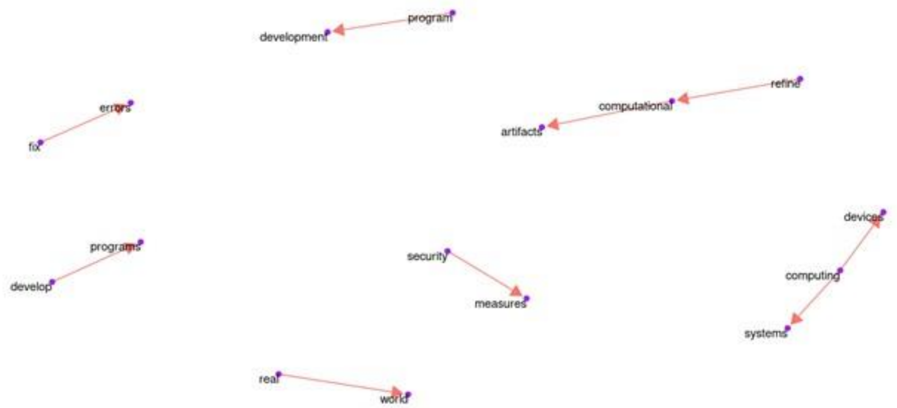


Figure 10. Visualization of bigram networks found in the CSTA learning standards.

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It is also worth noting that there are no areas of overlap between these bigram networks, as we might expect from the interrelationships between several of the core computer science concepts.

#### *4.2.3.Learning Standards – Verb Usages by Level, Concept, and Practice*

The frequency of verbs used in the text of the learning standards themselves was also analyzed and visualized along the dimensions of level, concept, and practice. These results are visualized in Figures 11, 12, and 13.

Figure 11 depicts the frequency of verbs in the learning standards along the dimension of level. This analysis reveals a progression in the number of verbs used in these learning standards as the grade levels increase, with the highest numbers of frequently used verbs occurring at the levels associated with high school (3A and 3B), and the lowest numbers of frequently used verbs found at the elementary levels (1A and 1B). Additionally, we can see that across the levels, these CS learning standards are asking students to act in consistent ways, with *create, model, design*, and *develop* occurring across the grade levels.

Figure 11. Visualization of Frequency of Verb Usage in the CSTA Learning Standards by Level

Figure 12 depicts the analysis of verb frequencies found in the CSTA CS learning standards along the dimension of concept. This analysis reveals that the concept *Algorithms& Programming* contains the highest number of frequently used verbs, and the concept *Computing Systems* contains the fewest. Interestingly, the remaining four concepts all have the same number of frequently used verbs (four each).


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Figure 12. Visualization of Frequency of Verb Usage in the CSTA Learning Standards by Concept

Figure 13 depicts the analysis of verb frequencies found in the CSTA CS learning standards along the dimension of practice. The computer science practices of *Developing & Using Abstractions* and *Communicating about Computing* demonstrated the highest numbers of frequently used verbs, and the practice *Fostering an Inclusive Computing Culture* demonstrated the fewest with exactly one (*evaluate*). As with the verb frequency analyses for level and concept, this analysis reveals a distribution of some common verbs across this dimension, such as: *develop*, *evaluate*, *describe*, and *discuss.*

Figure 13. Visualization of Frequency of Verb Usage in the CSTA Learning Standards by Practice

***4.3.The Text Used in the Clarifications to Each Learning Standard***

Each learning standard in this document is accompanied and enhanced by what the document calls *clarifications*. In the absence of an executive summary, as in the New York State Computer Science/Digital Fluency standards, which might outline the guiding vision and principles of a learning standards document [6], the CSTA learning standards document features what it refers to as clarifications for each CS learning standard. These clarifications expand and contextualize the specific learning standard (see Figure 2 for an

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example). The text of these clarifications was analyzed in order to investigate word frequencies by level, concept, and practice, as well as to explore the networks of word pairs therein.

#### *4.3.1.Clarification Text - Word Frequencies by Level, Concept, and Practice*

The word frequencies used in the text of these clarifications were analyzed and visualized, as was that of the learning standards themselves, along the dimensions of grade level, computer science concept, and computer science practice. The visualizations of these analyses are depicted in Figures 14, 15, and 16.

Figure 14 shows the visualization of word frequencies for the text of the learning standards clarifications along the dimension of grade level. This visualization reveals several trends. First, in every level except 3B (grades 11-12), *students*is the most frequently used word. In the elementary levels (1A and 1B), we see many of the same words occurring most frequently, such as: program/programs, information, data, and *computing*. In the middle school level (2), there is a repetition of many of the most words most frequently found at the elementary level, in addition to some new words, such as: *devices*, *people*, and *user*. In level 3A (grades 9-10), we see the widest distribution of frequently used words, while level 3B (grades 11-12), we see the narrowest distribution of frequently used words.

Figure 14. Word Frequencies of CSTA CS Learning Standards Clarifications Text by Grade Level

Figure 15 shows the visualization of word frequencies for the text of the learning standards clarifications along the dimension of computer science concept. Once again, this visualization reveals several trends. First, the concept Data & Analysis exhibits the least amount of frequently used words (two, data and students), while the concept Algorithms & Programming exhibits the greatest amount of frequently used words. In descending order, the middle three concepts with respect to word frequencies are Computing Systems, Impacts of Computing, and Networks & the Internet. This trend can be helpful in establishing the relative importance of these concepts in the learning standards themselves.

ISSN | Applied
Journal of E-Learning and Educational Technologies
Volume 1| Number 1| March, 2023
ZAP Journals

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Figure 15. Word Frequencies of CSTA CS Learning Standards Clarifications Text by Computer Science Concept

Figure 16 shows the visualization of word frequencies for the text of the learning standards clarifications along the dimension of computer science practice. As we have seen with the distribution of most frequently used words by grade level and computer science concept, this visualization reveals several trends.

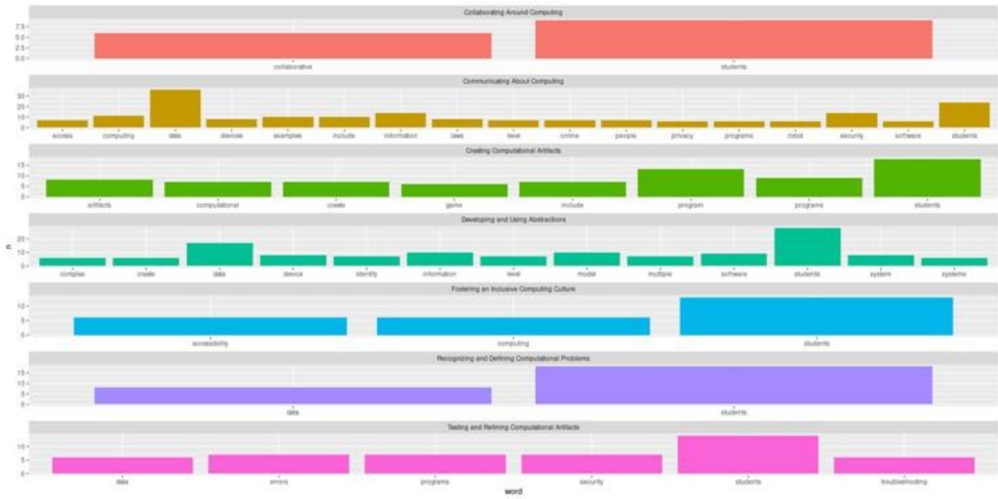


Figure 16. Word Frequencies of CSTA CS Learning Standards Clarifications Tex by Computer Science Practice

### *4.3.2.Clarification Text - Word Pair Networks*

An analysis and visualization of the bigrams found in the clarification text of the CSTA CS learning standards document was conducted using tidytext tools. The result of this analysis is depicted in Figure 17. This type of visualization is useful as it shows both the range of these concepts and topics, as well as their relationships to one another.

This network is far more extensive than that found in the text of the learning standards themselves, and appears to be organized as might be expected into topics that are related to computer science concepts, such as *program → development* and *implemented → physical → security→ measures*. Additionally, there are bigram networks that reflect computer science practices outlined in the document, such as *design→ process*,

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*computational → artifacts*, and *troubleshooting → strategies*. This network visualization depicts the breadth of this document's conception of computer science as reflected in the clarifications text. It is also important to note the relatively high density of this bigram network as compared to that visualized from the text of the learning standards themselves.


Figure 17. Visualization of bigram networks found in the clarifications text found in the CSTA learning standards document

## 5.CONCLUSIONS

In this section, we will discuss the findings of our close reading of the CSTA Computer Science Learning Standards. In this discussion, we will explore the findings and their implications for the learning of computer science by K-12 students in the United States, as well as implications for computer science teacher education and practice.

### *5.1.Coherence and Incoherence in the Standards and Clarifications Texts*

In his analysis of Common Core Learning Standards (CCLS) and their associated assessments,
Webb distinguished areas of of what he called Categorical Coherence and Domains of Knowledge (DOK) [22]. These word frequency and word pair analyses of the text found in the learning standards themselves as well as the clarifications provided for each learning standard is another way to investigate this type of coherence. For example, we can examine the word frequency analyses for the texts of the learning standards and clarifications across the computer science topics to determine if the most frequently used words are consistent with that topic.

These analyses for the concept Computing Systems are depicted in Figures 8 and 15, and contain terms that we would expect for such a concept: *hardware, software, computing, devices,* and *components*. This reflects two levels of coherence, that between the standards and the text clarifying the standards as well as within the concept itself – we see the terms we would expect to see. This trend is consistent across the other computer science concepts as well. Thus, we found the CSTA Computer Science Learning Standards document to contain a high degree of coherence along the dimension of computer science concept. We believe this level of internal coherence to be important in terms of describing the field of computer science as well as serving as a foundation on which curricula are to be developed by computer science educators.

### *5.2.Word Frequencies and Epistemic Spaces*

In addition to providing ways to analyze and determine levels of internal coherence between these computer science learning standards and the clarification text that accompanies them, this type of word frequency


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analysis also allows us to investigate the diversity and richness of the epistemic spaces defined and reflected by this document. Epistemic spaces circumscribe the understandings, concepts, and ideas within a domain of knowledge [24].

For example, we can look at the word frequency analyses for the learning standards and clarification texts associated with the computer science concept of *Algorithms & Programming*, depicted above in Figures 8 and 15. In both cases, the highest number of most frequently used words for each type of text is found in this concept. Certainly, this is an indication of the richness of the language used to describe it. In the language of the standards, we find a wide variety of verbs and nouns: create, design, develop, evaluate, refine, and solve; and algorithms, computational, development, procedure, and programs. In the language of the clarifications we find a similar variety, often of the same words. This breadth of word usage indicates a relatively broad epistemic space for this concept.

In contrast, the corresponding analyses of word frequencies concept *Data & Analysis* in the learning standards and associated clarification texts show far less variety and breadth. The most frequently used words for this concept in the standards are *data* and *tools*, and that for the clarifications texts are *data* and *students*. This lack of breadth implies, we believe, a deep focus in the language used for this concept and a specific focus in terms of student learning objectives.

Finally, we can compare the word pair (bigram) networks visualized for both the learning standards and the associated clarification texts. The visualization of the bigram networks in the learning standards depicted in Figure 10 reflects a narrow and concrete epistemic space – one that contains a relatively narrow range of word pairs, and these are mostly focused concretely on specific elements of the learning standards. In contrast, the visualization of the bigram networks in the clarification texts depicted in Figure 17 is larger, more dense, and less concrete, suggesting that these clarifications reflect a wider (and possibly complementary) epistemic space than that contained in the learning standards themselves.

### *5.3.Verb Usage and Cognitive Spaces*

The analysis of verbs used in the text of the learning standards themselves performed against the dimensions of grade level, computer science concept, and computer science practice revealed a wide cognitive world in terms of the levels of thinking skills outlined in Bloom’s taxonomy [23]. Bloom distinguished between lower and higher order thinking skills, and these orders are distinguished by the verbs describing the associated cognitive activity. Lower order thinking skills are associated with verbs such as *identify, define, describe*, and *explain*, while high order thinking skills are associated with verbs such as *analyze, design, construct*, and *evaluate*.

The visualizations of verb usage depicted in Figures 11, 12, and 13 demonstrate that these computer science learning standards reflect a balance of lower and higher order thinking skills across grade levels, computer science concepts, and computer science practices. This is in contrast to other such learning standards documents, such as that for New York [6], which are far more focused on lower order thinking tasks, such as *describe* and *explain*. These findings allow computer science teachers to freely design rich curricula and learning experiences and activities that occupy a wide cognitive space, while also being compliant with the CSTA CS learning standards.

### 5.4.Implications for Teacher Education and Practice

These analyses of the CSTA Computer Science Learning Standards have broad implications for teacher education and teacher practice. We believe that this type of computationally supported close reading of this unique type of document provides educators with a useful view of what such a document is saying about its conception of computer science concepts and practices, and how those should be taught to students in grades

K-12. Our hope is that our depictions of the internal coherence contained in this document, and the associated cognitive and epistemic spaces revealed will empower teachers to develop deep, rich, and meaningful curricular materials and learning activities that reach and engage all students. We are currently in the process of creating some model curricula to support these efforts.

## ACKNOWLEDGEMENTS

The author wishes to thank Tom Liam Lynch, Bret Staudt Willet, Carolanne DelGiudice, and Stephen Jacobs for their support with this project.

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**Journal of E-Learning and Educational Technologies (JEET)**
Volume.1, Number 1; March-2023;
Published By: Zendo Academic Publishing
https://zapjournals.com/Journals/index.php/jeet
14131 Alder St NW, Andover, Minnesota, USA
zapjournal@gmail.com, editorial@zapjournals.coom

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