Eurasian Journal of Educational Research 112 (2024) 31-57

Eurasian Journal of Educational Research
www.ejer.com.tr

Alignment of Digital Skills Textbooks with National Standards and SOLO Taxonomy of Observed Learning Outcomes Using Porter's Two-Dimensional Matrix

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ARTICLE INFO

Article History:
Received: 06 June 2024
Received in revised form: 09 July 2024
Accepted: 19 August 2024
DOI: 10.14689/ejer.2024.112.03

Keywords
Alignment Models, Learning Outcomes, Cognitive Levels, Digital Skills Textbooks.

ABSTRACT

Aim: This study aims to reveal the level of alignment of the content of digital skills textbooks for the middle schools in Saudi Arabia with national standards of digital technology and structure of observed learning outcomes (SOLO) taxonomy. **Method:** The sample of the study represented the population, which was digital skills textbooks for the middle school in Saudi Arabia. The study adopted a descriptive data content analysis approach and relied on Porter's model to measure alignment on two dimensions: content areas and cognitive levels, through variables namely, content of digital skills and technology textbooks. national standards of learning digital technology for the middle stage; and SOLO taxonomy. The data of the variables were analyzed through frequencies and percentages, and then Porter's equation was applied to find alignment between them. **Results:** The results revealed that there was no alignment between the content of the digital technology textbooks for the middle school with the national standards of digital technology learning. This was due to a different focus of content areas in the following branches: programming, computational thinking, artificial intelligence, digital citizenship, and cybersecurity. **Conclusion:** At the cognitive levels, a weakness was found in expanded thinking skills, associative thinking, and the focus of the content areas on the level of multi-structuring thinking, which is considered a beginner level. **Policy Implication:** In the light of these results, the study recommends reviewing the content of the textbooks in accordance with the recommendations provided, to ensure its alignment with the standard documents and focusing on the levels of expansive and associative thinking of cognitive levels.

Introduction

The educational environment in Kingdom of Saudi Arabia has greatly enhanced in recent years to meet the international standards and criteria. Besides, the Therefore, the Saudi education system, with all its elements, is engaged in a continuous development process, to

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make it consistent with the Saudi Arabia's Vision 2030, the twenty-first century skills, and to keep pace with renewable technology. For instance, the Ministry of Education has shown ample interest in the construction and development of textbooks, in accordance with the customized standards issued by the Education and Training Evaluation Commission (ETEC). The ETEC has developed some national standards for preparing educational materials, teaching them, and determining their content (Alasmari & Zhang, 2019; Alharbi, 2021). These standards specify what the learners should know and be able to perform; they are also important tools for measurement, and through these standards the quality of textbooks' content and their validity are judged (Al-Saadawi & Al-Shamrani, 2016).

In another instance, the ETEC developed a specialized learning framework for the branch of digital technology to come in effect from the year 2023, based on the latest educational trends and scientific research in teaching and learning digital technology (Alasmari & Zhang, 2019; Alharbi, 2021). This reflects the Kingdom's interest in teaching and providing learning opportunities in digital skills such as cybersecurity, digital citizenship, computational thinking, data science, and others. The scientific structure of computer science is rapidly changing and developing due to the cognitive era in which we live, and it is a cognitive and skill structure that is linked to the learner's life, both educationally and recreationally (Al-Tarshi, 2022). These initiatives reflect upon the need to review the curriculum content and ensure that it provides meaningful and interconnected educational experiences to both teachers and learners. In addition, the availability of learning domains like knowledge, values and skills in the content requires a diagnostic and therapeutic process to analyze it at the same time, develop textbooks, identify weak and strong points, and provide the basis for reviewing them, followed by deletion, addition, or modification (Al-Mu'tham, 2020).

There is no dearth of studies that have analyzed and evaluated the coherence of the content of textbooks with external sources such as specialized standards or international tests, or with internal sources such as the prerequisite elements of the educational process (Al-Sahem, 2022; Li et al., 2020; Qhibi, Dhlamini, & Chuene, 2020; Sun & Li, 2021; Yu, Li, & Li, 2022). In fact, several studies have shown concern for alignment with national and international standards in preparing the content; that have analyzed content accurately and calculated repetitions in content analysis cards coherently. A few research studies even developed a number of Alignment Indices Models, which are quantitative indices to investigate the correlation of textbook content with other variables such as standards and tests (Al-Suqairi, 2015; Li et al., 2020; Sun & Li, 2021). These studies based on alignment models also contributed to understanding the levels of variation and the intersections between the dimensions of the content of different textbooks according to specific criteria, identifying the most similar and different aspects between them, and how to develop them(Sun & Li, 2021). The results of these quantitative alignment model indices were found useful in knowing the effectiveness of the elements that were measured and compared with expectations or reality as essential features of an effective educational system (Bhatti, 2015).

However, all these studies have focused on measuring alignment of only one external source, namely identifying the level of alignment of curriculum content with national standards or finding linkages with any one of the variables like test standards, curricula standards, multiple thinking skills, or levels of cognition. Conversely, there is a recent trend to use alignment models on more than one dimension, such as the study by Sun and Li (2021), which used the Porter Alignment Model to create a two-dimensional matrix (the content dimension and the cognitive levels dimension). It relied on Anderson's taxonomy with the standards of science textbooks for the third grade of primary school and compared its alignment between China and Japan. The study of Yu et al. (2022) used the same model to construct a binary matrix. It relied on the central ideas as a cognitive dimension, and Bloom's taxonomy as a cognitive dimension. The analysis sample included biology curriculum standards for the secondary stage and five versions of the content of biology textbooks in China.

This study seeks to reveal the level of alignment of the content of digital skills textbooks for middle schools with national standards of digital technology learning in terms of the two dimensions of content areas and cognitive levels. To achieve these objectives, this study framed the following research question: What is the level of alignment of the content of digital skills textbooks for the middle levels in Saudi Arabia with national standards of digital technology learning in terms of content areas and cognitive levels? To probe deeper into the domain of digital technology learning in terms of the two dimensions of content areas and cognitive levels, the present study applied the alignment model classified with average complexity, which is the Porter Alignment Model matrix between educational elements. It is a matrix used to measure the level of alignment of educational elements and describe them in more than one dimension. The Porter matrix in this study, therefore, described three variables namely: the content of digital skills textbooks for the middle schools in Saudi Arabia, 2023 edition; the national standards of learning digital technology issued by the ETEC for middle schools; and SOLO Taxonomy levels for cognitive processes.

Literature Review

Wraga (1999) states that the term "curriculum coherence" has been widely used to indicate the internal alignment between the elements of the curriculum, which are objectives, content, activities, and evaluation. This use provides only a few ways of innovation, because the principle of unity and a comprehensive outlook between these elements is a research trend that has been approved for a long time. It also confirms that the concept of external alignment means compatibility between the curriculum with an external source, such as test standards, curricula standards, multiple thinking skills, or levels of cognition, is a recent research trend to develop the learning process (Al-Mu'tham, 2020; Darwaza, 2008). A few researchers have turned to content analysis studies with the aim of developing educational books. Attia (2008) mentioned the types of content analysis, including content analysis in the light of educational objectives, or the learner's needs and inclinations, or considering certain values, but the most prominent of them is content analysis in light of standards, whether local or global. The standards-based analysis process aims to improve the educational system, unify clear and accurate references, and identify the important elements of student education.

It is difficult to present the huge amount of knowledge and experiences to students in textbooks without measuring them with a specific reference such as standards (Al-Saadawi & Al-Shamrani, 2016), which are criteria that contribute to facilitating the measurement of achievement, developing textbooks, unifying and coherent provisions, which enable comparisons of local standards against international standards, especially standards for leading countries in developing curricula.

Difference Between Alignment, Evaluation, and Analysis

Content analysis was accompanied by the emergence of multiple vocabulary in related scientific studies, namely alignment, evaluation, and analysis (Al-Ghamlas, 2023; Hernández-Ascencio & Angel-Alvarado, 2022; Sun & Li, 2021). These studies are similar in steps, aiming to develop the content through sequential steps, and studying the relationship between the educational elements. However, these studies differ from the present research in the research tool, as the Porter Alignment Model was used, which aims to know the overlap and intersection between educational variables, their relationship to each other, and the degree of emphasis on them in the content. The results extracted from the models provide a more precise explanation. It reflects an integrated picture of the educational elements under study. Al-Mu'tham (2020), in another study, stated that it is a basic requirement to determine the level of alignment of books with standards emerging from the policy of educational systems, society's culture, and international tests. This will help in improving the outcomes of the educational system and unifying clear and accurate references.

The first step in coherence analysis is the categorization of all elements into smaller components such as carrying out the analysis process and studying the alignment of the parts and their interconnection with each other (Al-Mu'tham, 2020; Ma, Huang, & Hu, 2023). The inference drawn is that when studying the elements of the educational process, the subject must be studied in terms of quantity, to determine the extent of its presence in the content; in terms of quality, to judge the reality of its application to students; and in terms of its alignment with other components, to determine the possibility of its implementation in the educational environment. The interconnected content components contribute to maintaining the learning effect and forming an integrated cognitive structure for the learner. This is what Osbel emphasized in the theory of meaningful learning: presenting the educational material to students in an organized, ordered, and sequential manner to make it easy to recall, as the learner's mind is an organized structure, in which relationships and connections become clear. The learner receives knowledge hierarchically and stores it in cognitive structures. The major ideas and broad, more comprehensive or general concepts occupy the top of the pyramid, and the concepts graduate to detail and specification at the base of the pyramid (Al-Ghamlas, 2023; Beichi et al., 2024).

It is important to understand the measure of the strength of successful coherence between the elements of the educational process. It is inferred that greater compatibility between elements is better because there is no objective definition to evaluate the strength of alignment at a certain number (Fulmer, 2011; Jasim et al., 2024). However, continuous analysis and alignment studies are necessary to measure emerging changes in content and influential educational elements. Based on its results, elements such as standards and book content are modified and updated, and the best teaching methods are also adopted. Kazemi (2022) explained that the main goal of measuring the level of alignment does not just know whether the system is identical or only in agreement. Accordingly, studying alignment describes the relationship and the strength of the elements' connection and the influence of each other. Therefore, the main goal of alignment studies is for the teaching and learning message to be a message characterized by high alignment among teachers, students, parents, and administrators.

Types of Alignment Models

The International Journal of Science Learning has divided alignment models into three categories in terms of complexity, high, medium and low. The low complexity model depicts how consistent a test is with a content standard. It measures one dimension, often using a Likert scale, to indicate the degree to which an item matches a criterion. This scale may range from “not at all consistent” to “completely consistent.” This simple, or low-complexity, model forms the basis for all other models. This model is followed by the medium complexity model, which focuses on two or more dimensions such as content, standards, mental levels, or tests. The highly complex model, such as Porter’s model, looks at multiple dimensions of the relationship such as breadth of knowledge and compatibility, taking into account that the more complex the model, the less the probability of finding alignment. However, all models, in general, reveal strengths and weaknesses of the elements analyzed, and the extent of their alignment with each other, which contributes to the coherent flow of the educational process (Bhola, Impara, & Buckendahl, 2005; Ragusa & Crampton, 2022; Yu et al., 2022).

The alignment models are also classified based on the number of indices used for the alignment of the elements to establish a coherence between standards, assessments, and subject content. Examples are Achieve Alignment Model, SEC (Surveys of Enacted Curriculum) Model, Webb Alignment Model, and Porter Alignment Model. Each model consists of a series of indices that summarize or describe the alignment of the elements of the educational process, and the coherence between curriculum standards, assessments, and subject content. They can be used in a smaller scale by the teacher during classroom teaching. The proposed models facilitate the efforts made to develop the elements of the educational process, to improve teachers’ education in the classroom, and raise the level of educational achievement among students (Yu et al., 2022). All these models serve one main goal, which is to answer whether all educational elements are harmonious and work effectively.

The first model, the Achieve Alignment Model, focuses on comparing standards or grades for students’ achievement in different countries to determine a horizontal alignment. The model also reviews the results quantitatively and qualitatively. One of the studies that used the model is Rothman's (2003), which applied the achievement model to evaluate tests in five states. Rothman (2003) explained that alignment does not aim to answer yes or no, but rather to measure the aspects of it, whether the test measures all the criteria mentioned; or whether the tests and standards measure higher skills. The goal of alignment was not limited to evaluating students’ performance, but it also included evaluation of experts in terms of standards that were adopted for teachers in terms of tests that were set.

The second model, the SEC (Surveys of Enacted Curriculum) Model, was developed by Porter and Smithson (2001). It is a methodology for analyzing and measuring academic content and its level of alignment across educational elements, and identifying methods to improve alignment. The model consists of a two-dimensional grid, content (in rows) and expected learner performance (in columns). Predicting the learner’s performance means the cognitive level that the learner is expected to achieve. This model of alignment has several advantages: It shows the differences between the meeting points of the content and the expected level of performance, identifies good and weak points of alignment, and makes it easier for researchers, as well as practitioners, to interpret this data (Roach, Niebling, & Kurz, 2008).

The third model, the Webb model, was created in 1997 by Norman Webb, and was applied in more than 20 different states in the United States of America, to measure alignment between the elements of the educational process. The Webb model measures alignment in several items, including categorical alignment or representation of knowledge, depth of knowledge, and extent of scope of knowledge. Webb's model gives a quantitative measure of alignment that identifies intersections and points of emphasis in the items mentioned. In a number of studies that used the Webb model, it is classified as a qualitative measure because of its focus on cognitive depth through thinking processes (Qhibi et al., 2020), and its results include qualitative expert judgments with the results of quantitative analysis (He & He, 2023; Kazemi, 2022).

The fourth coherence model, Porter Alignment Model, uses two variables, namely: content and mental processes. Porter (2002) emphasized the importance of educational content as an important element in the study of coherence, and a major variable in students' achievement. Content alignment can be measured and compared with any educational element such as standards or assessments, and their frequency calculated in the Porter matrix (Kazemi, 2022). The results can later be extracted quantitatively and qualitatively. Porter alignment model is a much simpler process than the Webb model, in terms of the amount of analysis required, and analysis is faster, and reliability between analysts is faster to calculate (Fulmer, 2011). The Porter alignment formula produces a numerical index, in which the results range between zero and one. The index is compared with statistical indices such as the critical value or is treated as an independent index by measuring the level of verification. It means that one represents perfect alignment, and zero represents no alignment through the total difference between all cells (Contino, 2013; Osborne, Wood, & Ishak, 2022).

Areas of Application of Porter's Scale in Educational Process

Kazemi (2022) pointed out important points in alignment studies and elaborates how Porter's matrix enables measuring alignment between any two types, whether similar or different, of educational process elements. The Porter's model scale also presents a proposal for the index showing that it is possible to benefit from additional data provided by the matrix beyond the alignment of the elements. Multiple studies have used Porter's model in terms of the number of variables being compared, the results reached, and the number of analysts in each study. A few examples of areas of application of Porter's scale in the educational process include: (a) first, detecting the quality of educational practices, which means everything related to the educational process, such as: standards, content, assessments, and professional development. With the multiplicity of these variables, one might try to identify the strongest variable that influences teachers' teaching decisions, their educational practices, and other branches; (b) second, detecting the suitability of educational materials, which means that textbook content analyses can be used to evaluate the breadth and depth of the curriculum, or compare the curriculum with local or international tests or with standards; (c) third, the use of alignment index for detection and descriptive interpretation (the alignment index can also be used as a descriptive variable in evaluating the coherence of curricula, or their interrelation with other variables, political, social, or economic, such as the vision of the Kingdom of Saudi Arabia, labor market skills).

Before studying the alignment between the elements of the educational process, the researcher must ensure that the variables are of efficiency and quality, such as the realism of standards, and their ability to be achieved within the available resources such as teachers, school equipment, time, and educational methods, and their importance in the learning process, then study their alignment with the rest of the elements. All these previous variables are dynamic variables, suggesting that they are changing and renewable in the educational process, and studying their alignment at the present time results in different results after a period of time. This requires periodically studying alignment between educational elements to ensure their alignment and compatibility with each other. Before starting to study alignment, the researcher must also ensure that variables are of high importance and affect the educational process, that their quantity is comprehensive, broad, and diverse, and that the variables are qualitatively and quantitatively good.

The study of alignment also relies on a large content analysis or analysis of educational practices over the long term, so that the researcher can reach accurate results (Porter, 2002). Porter and Smithson (2001) recommend using cognitive levels during analysis, the purpose of which is to respond to criticism directed at the fact that the trend towards high alignment may weaken the amount of knowledge, standards, or tests. Ensuring that all cognitive levels are present and included in the content of educational books while studying alignment is an important topic. Biggs (2003) describes the taxonomies of knowledge, such as those of Bloom, Solo, and others, that they define levels of thinking and explain their gradation in the cognitive structure. The goals of these taxonomies vary. Some of them focus on measuring the student's cognitive quantity of learning or in the content, while other learning taxonomies are concerned with the quality of knowledge provided to the student in the content. There are other taxonomies that combine qualitative and quantitative for the purpose of measuring the knowledge provided quantitatively and qualitatively.

Solo Taxonomy of Learning Outcomes

Structure of the Observed Learning Outcome (SOLO) taxonomy, which appeared in the early 1980s, founded by Kevin Collis & John Biggs, is known to be an easy and effective way to explain how learning outcomes, or knowledge, grow from simple to deeper understanding, according to a progression of cognitive levels (Biggs, 2003). This kind of grading and measuring the cognitive levels in content areas enhances learning link information, develops experience, and makes it closer to reality (Fuller et al., 2007; Jimoyiannis, 2011; Muthuswamy & Sharma, 2024).

Hattie and Brown (2004) find the taxonomy of cognitive processes in four stages: (1) mono-structuring (stage of simple limited knowledge or superficial knowledge). This stage motivates students to march forward to the next level of learning, by building a stock of knowledge and collecting more information about the subject; (2) multi-structuring (stage of development) or the stage of deep knowledge or codified filling. When students move to the next level, it requires them to understand, assimilate and integrate knowledge, and put it in a coherent template in preparation for linking it with relationships; (3) associative thinking (constructive stage) or stage of linking knowledge. In this stage, learners link information, ideas and concepts to each other, and find the relationship between what they have learned and transferred understanding to application and practice; (4) expanded thinking (final stage) or stage of abstraction. In this stage, students' response goes beyond the problem to be solved and links the problem to a broader context so that students can extrapolate and move from part to whole, and from specific to general (Jimoyiannis, 2011). An example of this is when students employ what they have learned in other situations and are able to predict what would happen based on what they have learned.

It is noticeable that at all these four levels, the depth of cognitive levels increases with the increase in students' learning. In early stages, most of the learning is quantitative, and the amount of detail increases with the levels where quantitative learning in the Solo model aims to increase knowledge, while the qualitative dimension aims to have a greater understanding of knowledge, and both are main goals of the educational process. Hattie and Brown (2004) state that depth of knowledge is not the same as the state of difficulty, because the depth of knowledge increases with the qualitative change in the way ideas are understood, analyzed, assimilated and stored, their connection to other ideas, and the way they are recalled when needed (Biggs, 2003; Potter & Kustra, 2012). This is confirmed by what was mentioned in the study by Liu and Fulmer (2008) that merely covering topics cognitively is not a sufficient index of measuring students' achievement. Rather, covering all important topics and emphasizing the gradation of knowledge in them from simple to complex significantly predicts a student's successful performance and sequential cognitive structures.

According to Al-Sir (2019), the structure of knowledge has two dimensions, namely, the content areas and the organization of content. The content is viewed as a translation of learning standards, and it must consider the gradual aspect of the content structure and the depth of its cognitive levels. The content of textbooks in the Kingdom depends on documents issued by the ETEC, which specify both general and special standards for each branch of learning, divided according to academic grade. It also contains sub- objectives for each grade to accurately identify the stakeholders in the educational process. For the current study, the alignment of specialized standards in the branch of digital technology learning and their compatibility with the content of textbooks was determined, since the subject was important in an era with high technical aspirations, and its impact was reflected in learners' personal and professional life in future.

Methodology

Research Design

The research used the descriptive analytical method to describe and analyze the content of digital skills textbooks for the middle stage and their alignment with the national standards of digital technology learning issued by the Education and Training Evaluation Commission (second edition), and the SOLO learning outcomes structure. Prior literature defines the descriptive method in research as one of the forms of organized scientific analysis and interpretation to describe a specific phenomenon or problem and depict it quantitatively by collecting, classifying and analyzing data.

Sampling and Population

A purposive sampling was used to select the units with specific expertise and experience relevant to the study's objectives. This method, recommended by Patton (2015), ensures targeted and insightful data by focusing on objects that meet key criteria. The study population consisted of digital skills textbooks for the middle school in the Kingdom of Saudi Arabia 2023, a total of three textbooks. The study sample fully represented the population.

Data Collection

The data of the study comprised the content of digital skills textbooks for middle school for the year 2023. Based on the content, the number of textbooks, the number of units, and the number of pages were determined for middle school for the year 2023 (See Table 1) and for preparing the Matrix of Porter's model (See Table 2).

Table 1

Statement of the Content of Digital Skills Textbooks for Middle Schools

Academic stage/ Grade	Seventh	Eighth	Ninth	Total
Number of textbooks	1	1	1	3
Number of units	9	9	9	27
Number of pages	359	407	437	1203

Table 2

Matrix of Porter's Model

X Matrix	Mono-Structuring	Multi-Structuring	Associative Thinking	Expanded Thinking
Content area 1	0(0.0) [X1]	0(0.0) [X2]	0(0.0) [X3]	0(0.0) [X4]
Content area 2	0(0.0) [X5]	0(0.0) [X6]	0(0.0) [X7]	0(0.0) [X8]
Y Matrix	**Mono-Structuring**	**Multi-Structuring**	**Associative Thinking**	**Expanded Thinking**
Content area 1	0(0.0) [Y1]	0(0.0) [Y2]	0(0.0) [Y3]	0(0.0) [Y4]
Content area 2	0(0.0) [Y5]	0(0.0) [Y6]	0(0.0) [Y7]	0(0.0) [Y8]

Table 2 shows the search matrix consisting of rows and columns. The rows present the important pivotal ideas for the branch of learning digital technology while the columns show the SOLO learning outcomes in terms of structure taxonomy, consisting of four levels: mono-structuring, multi-structuring, associative thinking, and expanded thinking. The standards of learning digital technology (second edition) issued by the ETEC for the year 2023 are symbolized with (X), and the content of digital skills textbooks for the middle school are symbolized with (Y).

Data Analysis

Validity and Reliability of The Research Instrument, Porter's Matrix

Right at the outset, the validity and reliability of the research instrument, Porter's matrix, was derived. The variables that were used in this tool were (i) the national standards of digital technology learning issued by the ETEC, second edition 2023, which were prepared by the authority's specialists and subjected to multiple reviews by specialized experts in the branch; and (ii) digital skills textbooks for the middle stage approved by the Ministry of Education. To verify the reliability of the tool, the researchers relied on two types of reliability: Reliability across time and reliability across analysts. The reliability coefficient over time was conducted with a time difference of three weeks, and then the percentage of agreement between the two analyses was calculated using the holistic equation. It turned out that the value of the reliability coefficient over time was 0.89, which is an appropriate degree of confidence. The reliability coefficient across analysts was measured through the alignment matrix (Porter), which requires the presence of at least four specialized analysts to measure reliability, so that the same sample is analyzed by each analyst (Porter et al., 2008). Four researchers participated in analyzing the reliability sample, and the holistic equation was applied to verify reliability. It turned out that the value of the reliability coefficient across analysts was 0.86, which is an appropriate degree of confidence.

Extract the Calculation of Porter's Alignment Index

Porter's model was applied between two matrices: The first matrix (standards) was coded by X with the second matrix (textbooks) and denoted by Y. The following statistical procedures were used to extract the Porter index:

1. Calculating frequencies, extracting percentages, and reviewing graphs from Microsoft Excel.
2. Calculating the ratio of the frequency in each cell to the total, and then calculate the standard deviation and the absolute value of the variance.
3. Calculating the alignment coefficient using the law: $P=1-\frac{\sum_{i=1}^{n}|(X_I-Y_I)|}{2}$, interpreted as follows:

- n: the number of cells in the array, and i is associated with a specific cell ranging from 1 to n. The symbol sigma represents (the total sum of the cells of the matrix).
- Xi represents the ratio value of cell i of the first matrix (X), and Yi represents the ratio value of cell i of the second matrix (Y).
- Xi - Yi represents the difference between the proportions of the two corresponding cells in the two matrices, and the possible value ranges from 0 to 1.

4. The index was calculated on the values by comparing it to the critical value. If the alignment value is greater than the critical value, the index indicates the presence of alignment, and if the alignment index value is less than the critical value, the index indicates the absence of alignment.
5. Extracting the Porter alignment index requires generating 20,000 pairs of random matrices and then obtaining the normal distribution of the Porter alignment index, from which calculating the critical value (mean + 2 standard deviation) at the 0.05 level. If the actual value of Porter's alignment coefficient is greater than the critical value, this indicates its significance at the level of 0.05. This was calculated in the statistical programming language using the statistical program R (The R Project for Statistical Computing) (Fulmer, 2011; Li et al., 2020).

Results and Discussion

Extracting the Level of Alignment of the Content of the Digital Skills Textbook with The National Standards of Learning Digital Technology According to Content Areas and Cognitive Levels

To determine the level of alignment, the ratios of units for analyzing the content of textbooks and standards were used to calculate Porter's alignment coefficient between them, in addition to calculating the critical value of the coefficient at the level of 0.05, and the result became clear as presented in Table 3:

Table 3

Alignment Coefficient Between Digital Skills Textbooks and Digital Technology Learning Standards for the Middle Stage

Arithmetic mean	Standard deviation	Alignment coefficient value	Critical value
0.677	0.046	0.516	0.770

The results in Table 3 indicate that the alignment coefficient between the content of the textbooks and the standards document reached a value of 0.516, which is less than the critical value of Porter's alignment coefficient of 0.770 Figure 1. These results indicate that there is no statistically significant alignment at the 0.05 level of significance between the content and the document.

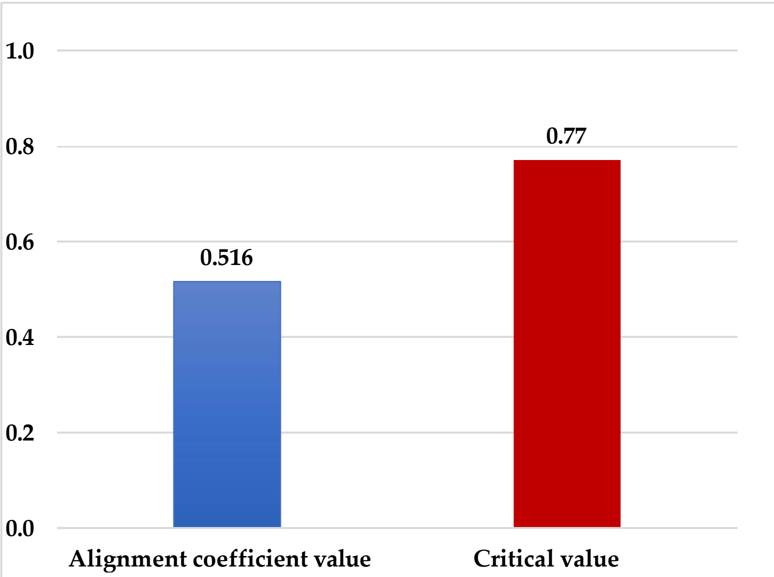

Figure 1: *Alignment Coefficient Between Digital Skills Textbooks and Digital Technology Learning Standards for the Middle Stage.*

It is clear from Figure 1 the difference between the critical value and the alignment coefficient. This study aimed to clarify the aspects of alignment by knowing the differences between content of textbooks and standards on the content areas dimension in two dimensions:

A. To determine the level of alignment of the content of digital skills textbooks with national standards in terms of content areas; and
B. To study the level of alignment of the content of digital skills textbooks with the Saudi national standards for the middle stage in terms of cognitive levels

In the first level (A), to determine the level of alignment of the content of digital skills textbooks with national standards in terms of content areas, the researchers compared the proportions of central ideas and branches between the content of the textbooks and the standards, as presented in Table 4.

Table 4

Percentage of Central Ideas/Branches for Digital Skills Textbooks and Standards for the Middle Stage and the Differences Between Them

Branch/ Central Ideas	Middle School Textbook	Standards for Learning Digital Technology	Difference
Digital systems and applications	0.372	0.266	0.105
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Digital systems	0.083	0.105	0.021
Digital tools and applications	0.288	0.162	0.127
Computational thinking, programming, and artificial intelligence	0.548	0.302	0.245
Abstractions and algorithms	0.029	0.102	0.072
Programming	0.311	0.075	0.236
Data	0.050	0.036	0.014
Artificial intelligence	0.158	0.090	0.068
Digital citizenship and cybersecurity	0.081	0.431	0.350
Digital citizenship	0.026	0.272	0.247
Cybersecurity	0.055	0.159	0.104

It is clear from the results of Table 4 that there is a difference in the percentage of the digital citizenship and cybersecurity branch (35.0%) in favor of the standards. We found that this difference results from the weak interest in skills textbooks in this branch, so the percentage of digital citizenship was (2.6%) and cybersecurity (5.5%) compared to the standards document. This difference leads to poor alignment. This suggests that the higher standards in this item than the content are due to the recent inclusion of cybersecurity in the standards document as an independent central idea. Under these new insertions, standards fall contrary to the content of the textbooks that mentioned digital citizenship and cybersecurity as concepts and lessons, with no separate unit allocated to them. However, it is a new entry into the educational process that receives international attention due to the digital transformation, cognitive revolution, and the importance of using technology carefully and safely (Al-Sahem, 2022).

The results also indicate that there was a difference in the percentage of the branch of computational thinking, programming, and artificial intelligence (24.5%) in favor of the content of the textbooks. It was found that this difference resulted from the difference in the percentage of programming ideas (23.6%), which led to weaker alignment. The high programming results may be explained by the fact that previous studies did not include artificial intelligence with the programming branch, and it was not mentioned as a central, independent idea also, since it was not mentioned in previous standards document. As for the present study, and according to the national standards of learning digital technology, second edition 2023, artificial intelligence was included as an independent idea under the branch (Computational thinking, programming, and artificial intelligence), which led to a significant increase in the percentage. Figure 2 shows a comparison of the alignment rates of the central ideas between the content of the textbooks and the standards.

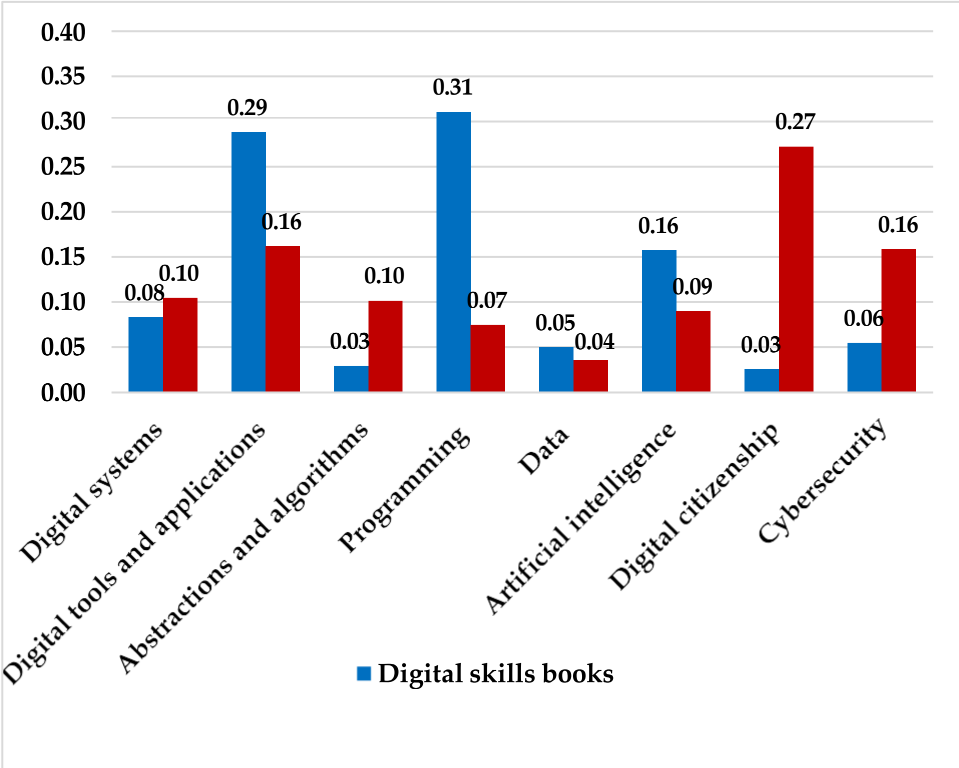


Figure 2: *Comparison of Alignment Rates of Central Ideas Between Digital Skills Textbooks and Digital Technology Learning Standards.*

Figure 2 shows that at the level of branches of knowledge structure, there are varying differences between textbooks and standards resulting in non-alignment between them. It is noticeable that there is a difference in the central idea of programming, digital tools and applications, and artificial intelligence, in favor of the content of the textbooks, while the standards focused on digital citizenship, cybersecurity, then tools and digital applications, then algorithms, and these ideas were largely omitted from the content. In addition, an alignment of some pivotal ideas between standards and textbooks, such as data and digital systems, was also noticed. It could be due to the reason that the lesser is repetition in the standards and content, the alignment becomes more apparent, and the greater are content and standards, the lesser becomes alignment. The size of the content and standards affect the level of alignment. This is consistent with the study of Liu and Fulmer (2008) that the greater the amount of analysis, the more difficult it is to match between cells. In addition, the more complex is the model, the less likely it is to find alignment (Bhola et al., 2005; Yu et al., 2022).

The model used in the current study is a medium complexity model. Figure 3 presents the level of alignment in the structure branches between the digital skills textbooks and the digital technology standards for the middle school.

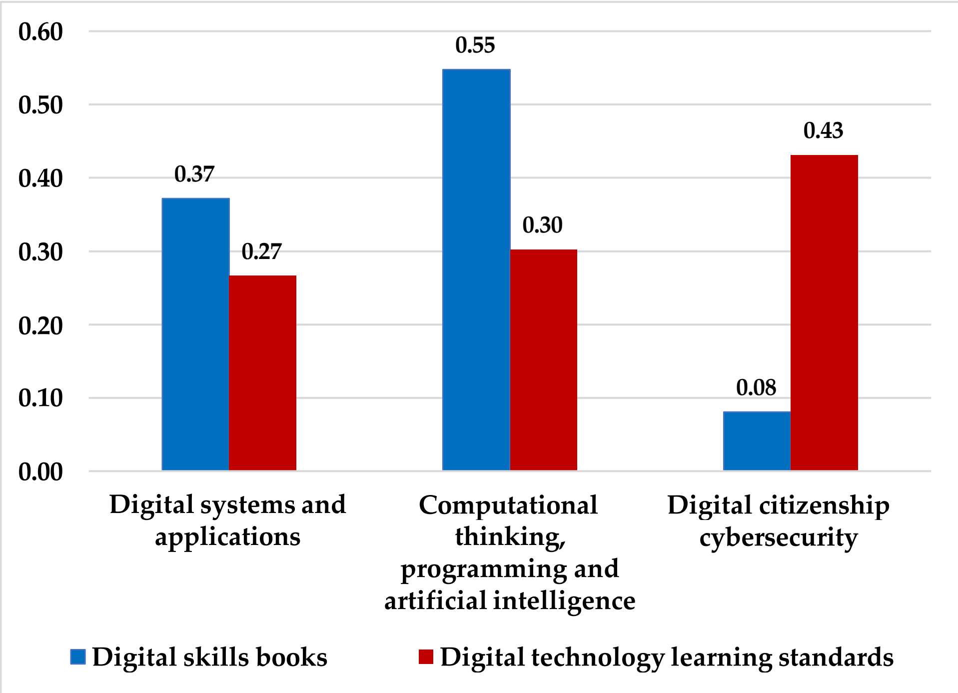


Figure 3: *Comparison of the Alignment Rates of the Branches Between the Digital Skills Textbooks and the Digital Technology Learning Standards for the Middle School.*

Figure 3 summarizes the presence of the branches in the content and the standards document. It demonstrates that the first branch, digital systems and applications, is present in a similar proportion in the content of the textbook and the standards document. The second branch, computational thinking, programming, and artificial intelligence, is more present in the content of the textbook than in the standards document. The third branch is digital citizenship and cybersecurity, which is more present in standards than in content, which weakens alignment.

The results also made evident that national standards reflect the state's vision and the socio-cultural context through high attention and highlighting of modern concepts such as cybersecurity and digital citizenship. When comparing this to the content of the textbook based on global standards, digital skills textbooks are books from a global series (Binary Logic, 2023), that have been translated and adapted to the local environment. They are textbooks older in version than the standards document issued in 2023 AD. The lack of alignment does not reflect a lack of efficiency or quality of the content or standards, but rather indicates that they are not interconnected. This is consistent with what Fulmer (2011) stated that there is no objective definition to evaluate the strength of alignment at a certain number in previous literature. However, continuous analysis and alignment studies are necessary to measure emerging changes in content and influential educational elements, and based on its results, elements such as standards and textbook content are modified and updated, and the best teaching methods are also adopted.

These findings are consistent with Al-Mu'tham (2020), who stated that the interest in determining the level of alignment of textbooks is a basic requirement for improving the outcomes of the educational system and unifying clear and accurate references. These findings also agree with the concept of positive alignment proposed by Biggs (2003), who stated that the goal of studying alignment is to develop educational elements in a way that makes it easier for learners to achieve the desired results, and not for the purpose of criticizing them and identifying their shortcomings. Kazemi (2022) explained that the main goal of alignment studies is not just knowing whether the system is identical or in agreement. Alignment studies describe the relationship and the strength of the elements' connection and influence on each other.

In the second level, to study the level of alignment of the content of digital skills textbooks with the Saudi national standards for the middle stage in terms of cognitive levels, alignment was extracted by comparing the proportions of different cognitive levels between the textbooks and standards, as shown in Table 5.

Table 5

Percentage of Cognitive Operations in Digital Skills Textbooks and Digital Technology Learning Standards for the Middle School and the Differences Between Them

Cognitive Levels	Middle School Books	Standards For Learning Digital Technology	Difference
Mono-structuring	0.224	0.251	0.028
Multi-structuring	0.654	0.479	0.175
Associative thinking	0.103	0.249	0.146
Expanded thinking	0.020	0.021	0.001

At the level of cognition, the results in Table 5 indicate agreement between digital skills textbooks and digital technology learning standards in the order of cognitive levels, as multi-structuring processes come in first place, followed by mono-structuring processes, then associative thinking, and finally expanded thinking. In addition, the results indicated that there was almost complete alignment in the level of expanded thinking processes between the textbooks and the standards, as the percentage of difference between them amounted to (0.1%). The results also indicated that there is alignment in the level of non- structuring processes between the textbooks and standards, with the percentage difference between them reaching (2.8%). However, the results indicated that there was a difference in the percentage of multi-structuring processes (17.5%) in favor of textbooks, as well as a large difference in the percentage of associative thinking processes (14.6%) in favor of digital technology learning standards.

In this level of analysis, Table 6 shows that the cognitive levels in the standards document are consistent with each other and are better distributed than the content of the textbooks. This requires including more sequential skills in the textbooks to raise learning outcomes and ensure alignment with the standards. It also requires greater focus on the balance of skills between levels. This does not agree with the study (Fuller et al., 2007; Jimoyiannis, 2011), which confirms that the progression to the deep approach and measuring the dimension of cognitive levels enhances learning, links information, develops experience, and makes it closer to reality. This difference in cognitive levels is reiterated in Figure 4.

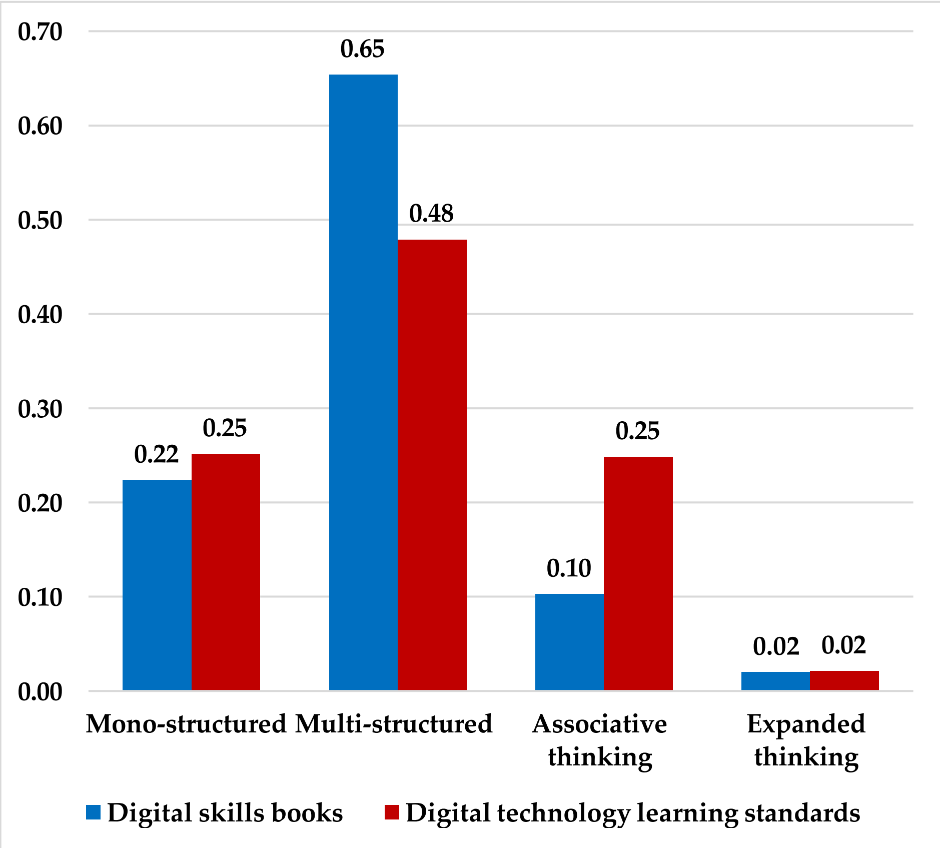
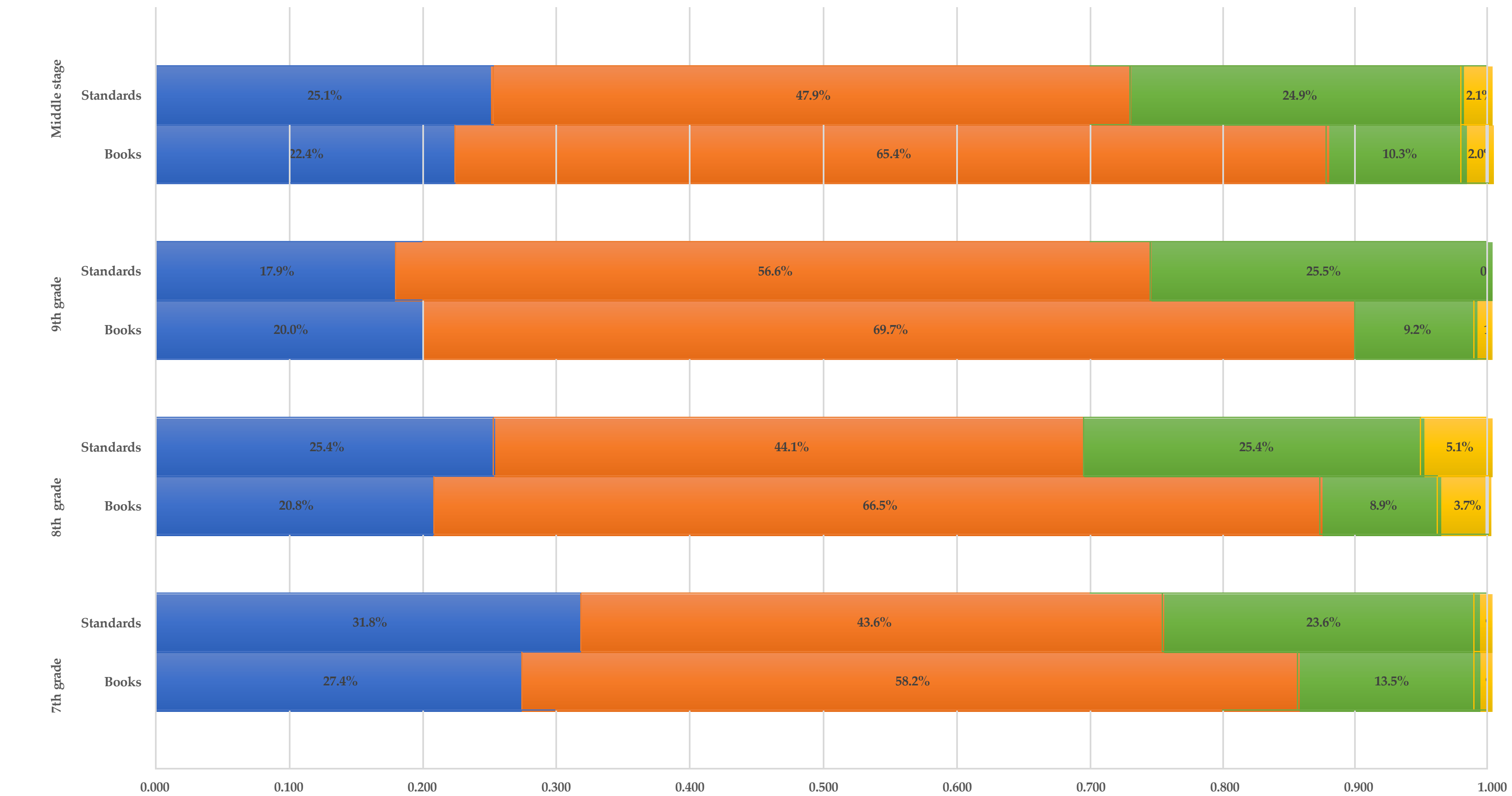


Figure 4: *Comparison of Alignment Rates of Cognitive Levels Between Digital Skills textbooks and Digital Technology Learning Standards for the Middle Stage.*

Figure 4 shows that the thinking skills that the learner acquires from the middle stage are reflected in the document and the content of the textbook are at a multi-structuring level. This indicates a large amount of knowledge for the purpose of memorizing and remembering without understanding, analyzing, assimilating, linking and evaluating. This weakens the cognitive structure and its recall by the learner.

It is evident from these results that some of the factors may have contributed to the weak alignment of cognitive levels, including the expansion and multiplicity of ideas for the purpose of covering a large amount of knowledge content. Some of these ideas may be new to the student, such as artificial intelligence and cybersecurity, which makes it difficult to delve deeply into the ideas, and thus the cognitive levels in the content are superficial. This is inconsistent with Potter & Kustra's (2012) study that understanding grows and deepens when going through different levels within the learning cycle repeatedly. That is new ideas and cognitive structures are introduced. To determine the level of focus in the content and document, a comparison was made between the percentages at the level of cognition for each grade as shown in Figure 5.

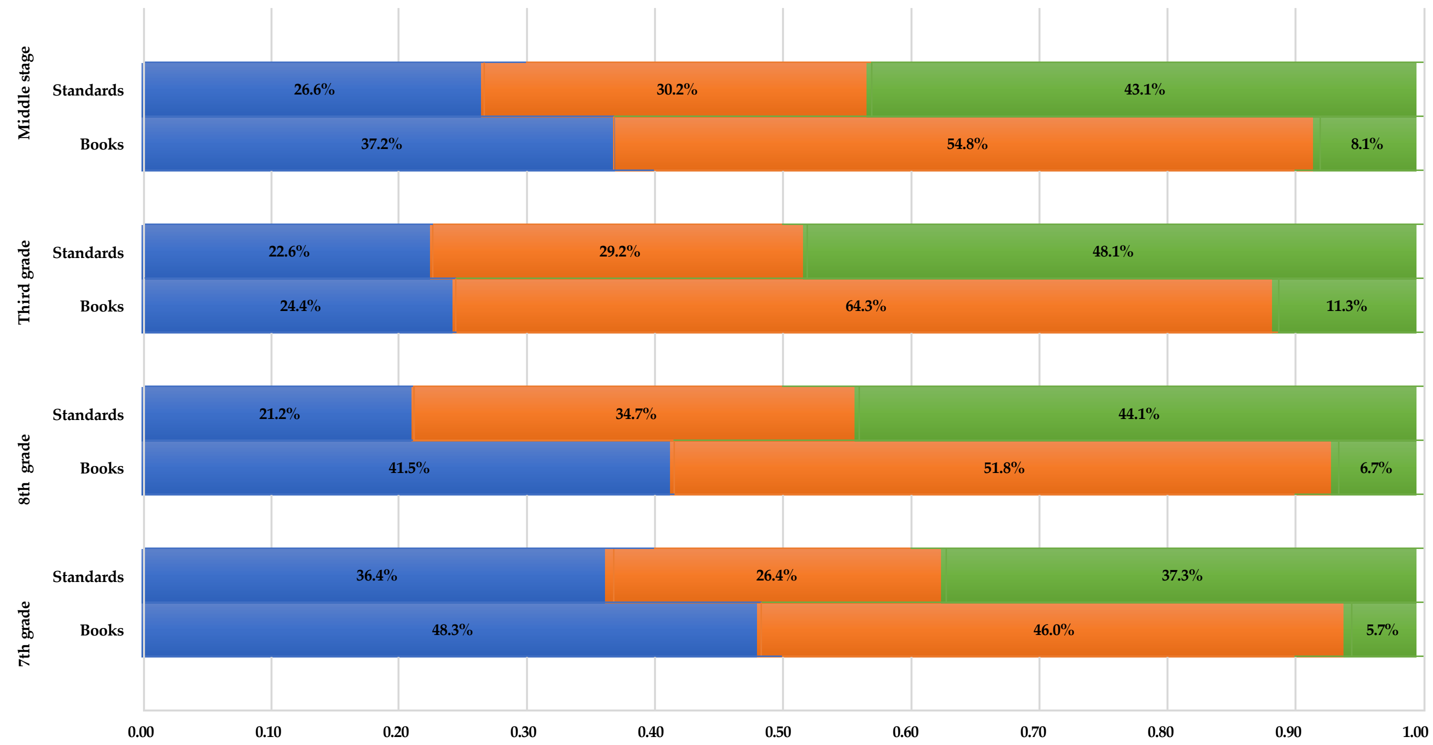


	7th grade		8th grade		9th grade		Middle stage	
	Books	Standards	Books	Standards	Books	Standards	Books	Standards
Mono-structured	27.4%	31.8%	20.8%	25.4%	20.0%	17.9%	22.4%	25.1%
Multi-structured	58.2%	43.6%	66.5%	44.1%	69.7%	56.6%	65.4%	47.9%
Associative thinking	13.5%	23.6%	8.9%	25.4%	9.2%	25.5%	10.3%	24.9%
Expanded thinking	0.9%	0.9%	3.7%	5.1%	1.1%	0.0%	2.0%	2.1%

Figure 5: *The Level of Focus on Cognitive Levels Between Digital Skills Textbooks and Digital Technology Learning Standards for the Middle Stage.*

Figure 5 shows that multi-structuring obtained the highest percentages in all textbooks and standards, which is approximately half, and weakness in expanded thinking skills. This does not agree with the study of Al-Suqairi (2015), which recommended including all skills in the content of textbooks and clarifying the interconnections and relationships between the parts, which makes it easier for the student to learn and comprehend them. It also does not agree with the prior studies, which stated that if the content exceeds the standards in cognitive levels, this indicates the ease of the content in this aspect or the repetition of information more than required. These findings confirm the second axis in the vision of the Kingdom of Saudi Arabia 2030, which is the flourishing economy, the importance of building an educational system linked to the needs of the labor market by preparing advanced educational curricula that focus on basic skills, in addition to talent development and personality building.

Figure 6 shows a comparison between the amount of knowledge in the document and the textbooks in some content areas.



	7th grade		8th grade		Third grade		Middle stage	
	Books	Standards	Books	Standards	Books	Standards	Books	Standards
Digital systems and applications	48.3%	36.4%	41.5%	21.2%	24.4%	22.6%	37.2%	26.6%
Computational thinking, programming and artificial intelligence	46.0%	26.4%	51.8%	34.7%	64.3%	29.2%	54.8%	30.2%
Digital citizenship cybersecurity	5.7%	37.3%	6.7%	44.1%	11.3%	48.1%	8.1%	43.1%

Figure 6: *Comparison of Alignment Rates of the Content Areas Between Digital Skills Textbooks and Digital Technology Learning Standards for the Middle Stage.*

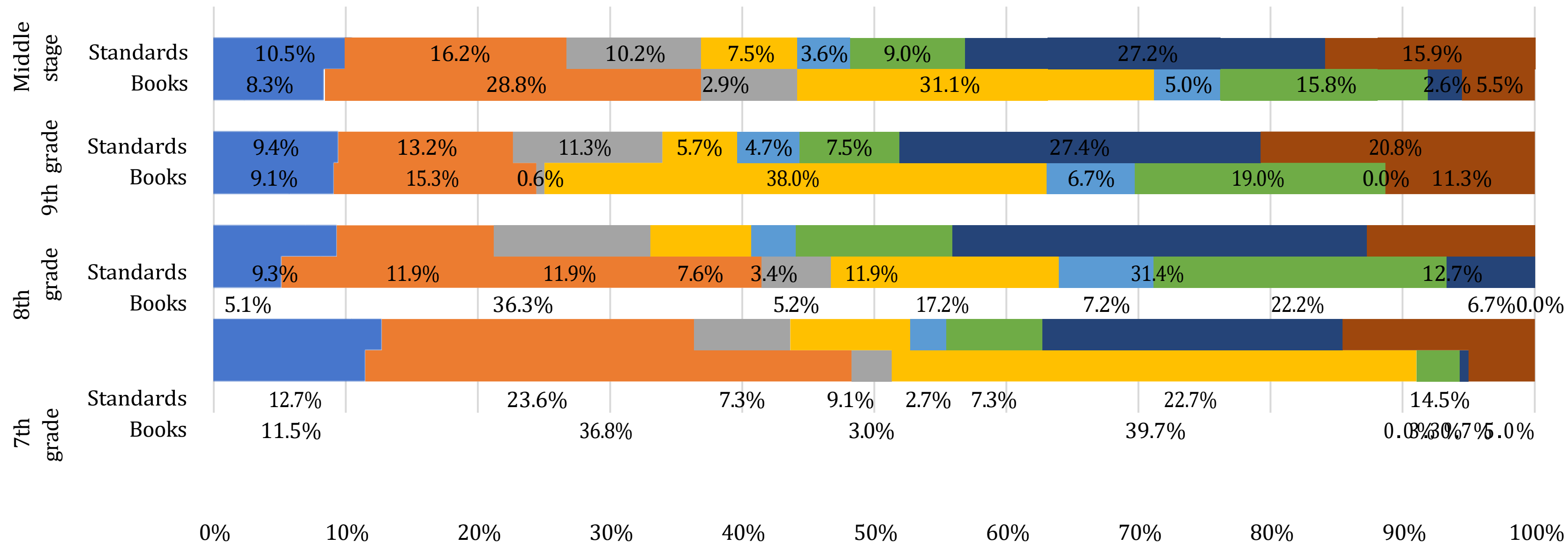
When comparing the three basic branches, it becomes clear that the digital citizenship and cybersecurity branch is not consistent between standards and textbooks. This is in line with the study of Al-Awfi and Al-Zahrani (2021) for the third middle grade; for the second middle grade; the study of Al-Ghamlas (2023) for the middle stage; and the study of Al- Fayez, Al-Othman and Al-Malihi (2021), for the fifth grade of primary school. It was evident that the low percentage in content was due to the presence of textbooks specialized in this branch at the secondary level, which would be expanded later. Moreover, the high percentage of standards was due to the interest of officials in the standard, which is a reflection of the social context in its importance and political strengthening of the state from the Kingdom's Vision 2030, and its economic impact as the branch of cybersecurity has become a requirement in many jobs.

Figure 6 also shows the lack of alignment in standards and content of textbooks in the branch of computational thinking programming and artificial intelligence. It is available in the content in greater proportions than in the standards document, but its percentage of 30.2% in the document is considered a good percentage, as it is equivalent to approximately one-third. The researchers explain the result of the high percentage of programming in content for three reasons: *First*: According to what Piaget stated, the student's cognitive development changes from concrete things to abstract intelligence (Ibrahim & Shaheed, 2020). In the primary stage, concrete concepts are mentioned, such as computer components, programs, etc., and in the middle stage, the focus is on programming and computational thinking. *Second*: the computer subject previously focused on the hardware and software components, and then programming was introduced to enhance students' skills, which coincides with the qualitative shift in education from theory to skills. *Third*: programming is an enjoyable and attractive subject for students.

Figure 6 also shows a lack of alignment, which is the least in the digital systems and applications branch. However, their availability in the textbook and standards at approximately one-third is considered appropriate for the age group, especially since this branch and the important standards it contains such as production tools, research, communication, networks, and software are structural knowledge. It starts with the student from elementary school and grows through the grades. It is consistent with what was mentioned in the Specialized Framework Document for Learning Digital Technology (2019) that the branch of digital applications constitutes a high percentage in the primary and middle stages to provide the learner with basic skills in dealing with devices and applications and how to employ them in other areas of learning and daily life.

Figure 7 shows the alignment of each central idea contained in the content of the textbook and the standards document. It shows the levels of the central ideas in each textbook according to the academic grade with the total for the middle stage and comparing them to the standards levels, noting that the percentage is not mentioned if it is less than 3% to clarify and ease reading the data. In the first pivotal idea, digital systems and applications, it became clear that the standards are consistent in proportion to each other, and the content of the textbooks between them is reasonably consistent. However, the weakest alignment is in the content of eighth-grade textbooks reached a rate of 5.1%. This percentage was not consistent with the standards or the content of the textbooks. It is evident from this finding that when the content of the textbook is raised in the central idea of digital systems and applications for the eighth grade in a manner that is consistent with the remaining percentages, it will contribute to raising the overall alignment percentage.

In the second central idea, digital tools and applications, it was evident that there was a difference in proportions after comparing standards and textbooks, and curriculum developers must take into account their alignment with the standards, and take into account the cognitive balance at the classroom level. It is an important and complex central idea since applications are a broad branch that includes production tools such as Microsoft Office programs and its various tools. It also includes tools for communicating on the Internet, sharing, and searching, so the diversity of the idea has created many iterations of it.



	7th grade			8th grade			9th grade			Middle stage		
		Books	Standards		Books	Standards		Books	Standards		Books	Standards
Digital systems		11.5%	12.7%		5.1%	9.3%		9.1%	9.4%		8.3%	10.5%
Digital tools and applications		36.8%	23.6%		36.3%	11.9%		15.3%	13.2%		28.8%	16.2%
Abstractions and algorithms		3.0%	7.3%		5.2%	11.9%		0.6%	11.3%		2.9%	10.2%
Programming		39.7%	9.1%		17.2%	7.6%		38.0%	5.7%		31.1%	7.5%
Data		0.0%	2.7%		7.2%	3.4%		6.7%	4.7%		5.0%	3.6%
Artificial intelligence		3.3%	7.3%		22.2%	11.9%		19.0%	7.5%		15.8%	9.0%
Digital citizenship		0.7%	22.7%		6.7%	31.4%		0.0%	27.4%		2.6%	27.2%
Cybersecurity		5.0%	14.5%		0.0%	12.7%		11.3%	20.8%		5.5%	15.9%

Digital systems | Digital tools and applications | Abstractions and algorithms
Programming | Data | Artificial intelligence
Digital citizenship | Cybersecurity

Figure 7: *Comparison of Alignment Rates of Central Ideas Between Digital Skills Textbooks and Digital Technology Learning Standards.*

The third central idea, abstraction and algorithms, means dividing large and complex problems and design algorithms. It was noted that they are among the least presented ideas in textbooks and standards, and this may indicate the small age group for this skill, as well as the fact that it is a skill related to another skill, which is programming. Figure 7 shows the differences in proportions between grades at the level of standards and textbook content, which weakened alignment. This is consistent with the other prior studies regarding the weakness of abstraction skills in the ninth grade. It is also classified as a higher-order thinking skill based on its weak availability. They are associated with weak cognitive processes in expansive thinking.

The fourth central idea is programming. It is what the textbooks focused on and received the highest percentage in content, but its focus in standards was less. The difference in focus between standards and content hinders stakeholders in making important decisions for education. Based on the content, the teacher sets tests and goals and determines learning outcomes. In the fifth pivotal idea, data, which was the weakest of the pivotal ideas, the data was collected for the purposes of simulation and modelling. This pivotal idea constitutes an introduction to the next pivotal idea, which is artificial intelligence. It should be noted that data science is a branch that is widely spread as a pivotal idea in education. Through this science, more than one subject, such as mathematics, can be integrated because it focuses on analysis, technology, and artificial intelligence. It also relies on high skills such as taxonomy, grouping, abstraction, etc. Data science is also an important science in machine language (Podworny & Fleischer, 2022), which calls for the importance of presenting it in interconnected and ways, which facilitates learning for the student and connects him to aspects of life.

In the sixth central idea, artificial intelligence (AI), it was noticed that the textbook focuses on AI more than the standards, and a noticeable decrease in the idea in the seventh grade. It was thus evident that the result was due to the small age group that is the subject of the study, and the standards must be compatible with the textbooks due to the high percentage of this branch, which is an important trend in the educational process. The standards document, the second edition, allocated a special central idea to it and included in the name of the branch along with programming and computational thinking. In the seventh central idea, digital citizenship, a significant difference in the ratios between standards and textbooks in all chapters and the stage in general was noticed. This differs from Al-Fayez's (2021) study of fifth-grade primary school books, which may be due to the difference in the study sample and the edition of both the document and the textbooks being different editions. This is consistent with studies (Al-Awfi & Al-Zahrani, 2021; Al-Ghamlas, 2023), regarding the low percentage of digital citizenship in middle school books. It is evident in these findings that in the light of technological challenges and digital development, it is necessary to pay attention to including digital citizenship concepts in the content of school books in a way that suits the characteristics of growth, the target age group, and the progression of concepts, with an emphasis on balancing the proportions of standards in the document and not focusing on specific standards.

In the eighth central idea of cybersecurity, there is a large difference in standards and textbooks, which also contributed to reducing the level of alignment. It was noticed that the document focuses on this branch by 15.9% and a decrease in textbooks by 5.5%. The researchers explain the low percentage for two reasons. The first is the relative newness of the concept and therefore the content may not be as available as in previous concepts. The second is the young age of the target age group and their sufficient understanding of this axis; whereas the middle stage is a stage of establishing and building basic knowledge and skills, while specialization is in the higher stages (Al-Awfi & Al-Zahrani, 2021), which was observed after the textbook development series in the Kingdom of Saudi Arabia by allocating a course that studies cybersecurity independently in the secondary stage.

Figure 8 shows the similarities and differences between the standards document and the content of the books. The overlapping area between the two circles shows the alignment in the basic concepts and skills mentioned in the content and the document, and the different area between the two circles shows the different concepts and skills that each of the books and standards focused on.

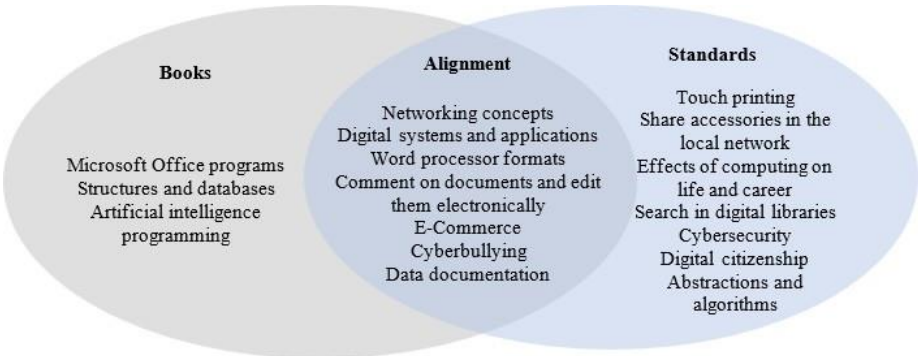


Figure 8: *Venn Model for Determining Alignment Between the Standards Document and the Content of Books for the Middle Stage.*

It is clear from Figure 8 that there are concepts included in both the document and the content of the book for the middle stage, but there are a large number of important and modern concepts in the branch of learning digital technology that were focused on in the standards document and were omitted from the content of the books. This requires reviewing and amending the content of middle school books to suit the central ideas and main concepts contained in the document.

Conclusion

This study focused on the lack of alignment between content areas and cognitive levels, as well as between the content of textbooks and standards. This resulted in the focus being on the skill of multi-structuring thinking and a lack of higher skills such as associative thinking and expanded thinking. The lack of alignment between the content of textbooks and standards also conveys the message that the content and cognitive levels that the teacher provides to the student is different from what is required in the standards document issued by the ETEC. This leads to learning outcomes from schools that are not consistent with the learning outcomes expected from the higher authorities that build standards. This may make the student face difficulty in completing international or local tests based on national or international standards because they are not compatible with the cognitive and skill content presented to him in the content of textbooks.

The textbooks also focused on the basic concepts in learning digital technology, and these concepts were discussed in the previous standards document for the branch of learning digital technology. This explains that the content of the books has not been updated and developed in a way that ensures the inclusion of modern concepts included in the national standards of learning digital technology (second edition 2023). Moreover, work is also being done to classify the standards in the document according to thinking skills, such as using Bloom's or Solo's taxonomy or others, clearly and explicitly for the curriculum designer, in addition to identifying the targeted learning areas for each cognitive level. This helps focus on the content of the standard and the cognitive level targeted in it.

This taxonomy of standards according to learning outcomes is approved in several documents, such as The Digital Competence Framework, which aims to determine levels of digital competency by dividing competency into knowledge, skills, and values, and grading each competency in cognitive operations from beginner (1) to proficient (8). It is also approved in the report issued by the ETEC in 2023 entitled (Learning Outcomes for National Tests), which aims to reveal the level of learners' achievement of basic learning outcomes in the areas of reading, mathematics, and science according to national standards. The document clarified the content areas in each of the three basic subjects. Three cognitive levels are mentioned: knowledge and understanding, application, and reasoning.

The standards document must be accompanied by models to measure its alignment in content, whether from document preparers, curriculum developers, or supervisors. International documents have emphasized the importance of accompanying frameworks and standards with tools that facilitate the self-evaluation process. Examples of those documents are the model for alignment between standards and content on standards website of the Computer Science Teachers Association (CSTA), and the Digital Competence Framework model issued by the European Union Office, which provides the option of creating examples for each standard from the book to ensure alignment. Another example is the alignment model of International Society for Technology in Education (ISTE) attached to the standards document. One example is the inherent ideas in artificial intelligence included in the secondary school teachers' guide for the practical application of artificial intelligence projects.

Moreover, presenting the standards in a broader way than using a file reading program (PDF), such as presenting them electronically in drop-down lists for the purpose of ease of access and application are extremely important. This is done by creating a special link to book standards, which contains drop-down lists. The user selects the specialized subject, then chooses the academic grade, the branch, the central idea, and then reviews the standards attached to it. Finally, the standards document has achieved a high level of awareness and comprehensiveness in the various branches and reflects various skills and values of the learner related to the nature of the era in which they live, especially in digital citizenship and cybersecurity. However, the focus on it has caused the neglect of some other pivotal skills and ideas, such as programming, computational thinking, and dealing with data, which are important skills for the learner.

The study would like to recommend that a team of curriculum standards designers and developers should present the document's standards according to the structure of education curriculum standards, which are (knowledge, skills, and values), as explained by the National Framework for General Education Curricula Standards in the Kingdom of Saudi Arabia, second edition, considering their gradation in cognitive levels. It is believed that linking them to the standards is important because they are the result of what the learner knows, understands, and can do in every branch of learning, including knowledge, skills, and values acquired at the end of the grade or level. Further studies may also be conducted regarding the alignment of the content of computer books with national and international tests, including data science, computational thinking, and abstraction skills in the content of textbooks and document standards.

A few other recommendations can be stated for curriculum designers and developers like (1) developing the content of digital skills books in the middle stage in accordance with the national framework standards of learning digital technology, as it is an updated reference that is compatible with the state's efforts in developing education; (2) making the development and improvement process continuous throughout the year, as it is digital content that can be updated faster; (3) supporting the content area and cognitive levels in the branch of cybersecurity and digital citizenship with positive values such as honesty, taking responsibility, respect, and societal responsibility, and not simply clarifying them through adverse behavior such as electronic bullying, digital plagiarism, and security breach; and (4) supporting the content with computational thinking and data science skills because they exist in small quantities, and these are important skills and knowledge in problem solving, decision making, and future jobs.

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