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Effective Information Retrieval for Mobile Misinformation Identification

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Abstract: Misinformation is always a serious problem for the general public, especially during pandemic. People constantly receive text messages of related coronavirus news and its cures from their smartphones, which have become a major device for communication in these days. These health text messages help people update their coronavirus knowledge repeatedly and better manage their health, but some of the messages may mislead people and may even cause a fatal result. This research tries to identify mobile health text misinformation by using various effective information retrieval methods including lexical analysis, stopword removal, stemming, thesaurus discovery, and message similarity measurements. Readers will learn various information retrieval methods applied to contemporary research: mobile misinformation detection. Experiment results show the accuracy of the proposed method meets the expectation, but still has room for improvement because misinformation detection is intrinsically difficult, and no satisfactory methods have been found yet.

Keywords: COVID-19, Misinformation, Mobile Misinformation Detection, Sentence Similarity, Mobile Computing

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Introduction

By October 2022, coronavirus had infected more than 626 million people and killed more than 6 million human beings in the world. It has completely changed our lives. Amid pandemic, people are becoming more aware of their health and well-being. They check the health and coronavirus news constantly, especially via their smartphones which have become indispensable devices for people. Other than useful and true health information, these devices also deliver misinformation or fake news, which not only misleads people, but also may cause fatal results. For example, many people refuse to take COVID-19 vaccines because of the concerns of safety and effectiveness. Much of the information they receive may come from mobile text messages from their relatives, friends, subscribed news, etc. This research tries to help relieve the problem by using various

information retrieval technologies to identify mobile health text misinformation. Therefore, users can take appropriate actions like ignoring the fake messages or referring other sources such as the Internet to verify the misinformation according to the recommendations.

This research tries to classify a mobile message as one of the five classes (true, fake, misinformative, disinformative, and neutral) and notify the mobile user about its finding, so the user can take an appropriate action like ignoring the message or forwarding it to others. Each message will go through a series of steps: (i) preprocessing (including lexical analysis, stopword removal, stemming, and synonym discovery), (ii) indexing and storage, (iii) classification by using four message similarity measurements (keyword, phrase, LCS (longest common subsequence), and LACS (longest approximate common subsequence) matching), and (iv) finally a final class recommended from a function of data fusion taking accounts of the four similarity scores. Preliminary experiment results show the accuracy of the proposed method meets the expectation, but still has room for improvement. An explanation for this may be because the short messages do not provide much information and small deviation may cause a great impact on the results. Further refinements are needed before it is put into effective use.

The rest of this paper is organized as follows. Section 2 shows the background information about this research and related works on misinformation detection. The flow diagram and the pre-processing components (including syntax analysis, stopword removal, stemming, and synonym discovery), and indexing and storage of the proposed system are given in Section 3. Section 4 discusses the data fusion function and the four message similarity measurements for detecting health text misinformation. The experiment results and evaluations are given in Section 5, followed by a conclusion and references.

Background and Related Literature

This section gives the background information of this research and related research in case readers are interested in finding more relevant publications. Misinformation detection is critical and popular in these days because information could be created and sent by everyone, not just news agencies, and some may distribute misinformation unintentionally or intentionally. Many methods are used to detect all kinds of misinformation like politics, businesses, text messages, emails, or news. This research places the focus on mobile health text misinformation identification. If the results are favorable, the method may be extended to other kinds of information. Yu, Liu, Wu, Wang, & Tan (2019) propose an attention-based convolutional approach for misinformation identification model. An *Event2vec* module and the co-attention contribute to learning a good representation of an event. A convolutional neural network then extracts key features scattered among an input sequence and shapes high-level interactions among significant features, which help effectively identify misinformation and achieve practical early detection. An attention-based approach for identification of misinformation (AIM) is proposed by Liu, Yu, Wu, & Wang (2018). Based on the attention mechanism, AIM can select microblogs with the largest attention values for misinformation identification. The attention mechanism in AIM contains two parts: content attention and dynamic attention. Content attention is the

calculated-based textual features of each microblog. Dynamic attention is related to the time interval between the posting time of a microblog and the beginning of the event. More generic misinformation detection can be found from the articles (Sharma, Qian, Jiang, Ruchansky, Zhang, & Liu, 2019; Zhou & Zafarani, 2020; Khan, Michalas, & Akhunzada, 2021; Savage, 2021).

This research focuses on coronavirus misinformation detection. Brennen, Simon, & Nielsen (2021) analyze visual content in misinformation concerning COVID-19. They use a mixed-method analysis of ninety-six examples of visuals in misinformation rated false or misleading by independent professionals. It shows the value in both attending to visual content in misinformation and unnecessarity of a concern with only the representational aspects and functions of misinformation. Another study by Gupta, Gasparyan, Misra, Agarwal, Zimba, and Yessirkepov (2020) identifies social media as a potential source of misinformation on COVID-19 and a perceived high risk of plagiarism. More stringent peer review and skilled post-publication promotion are advisable. They recommend editors should play a more active role in streamlining publication and promoting trustworthy information on COVID-19. Gisondi, etc. (2022) examine the social media companies play in the COVID-19 infodemic by showing how fake news about the virus developed on social media and acknowledging the initially muted response by the scientific community to counteract misinformation. The authors then describe legal and ethical imperatives to challenge social media companies to better mitigate the COVID-19 infodemic. Finally, they close with recommendations for social media companies to better partner with community influencers and implementation scientists. Related research about coronavirus misinformation identification can be found from the articles (Mian & Khan, 2020; Fleming, 2020; Ball & Maxmen, 2020; Vuong, *et al*., 2022; Roozenbeek, *et al*., 2020).

The Proposed System

The proposed system includes many complicated components, so this paper tries to introduce it by using two sections. The pre-processing functions (including lexical analysis, stopword removal, stemming, and synonym discovery) and indexing and storage are explained in this section. The data fusion function and the four message similarity measurements (including keyword, phrase, LCS, LACS matching) will be given in the next section.

The Five Mobile Health Text Message Classes

A mobile health text message can be classified as one of the following five classes:

- *True*, which is true information and is without a doubt. For example, it is true that a vaccine to prevent COVID-19 is available because COVID-19 vaccines have been authorized by the U.S. Food and Drug Administration (FDA) and vaccine programs have begun across the country.
- *Fake*, which could be either misinformation or disinformation. For example, it is an obviously fake news that the COVID-19 vaccines contain microchips for government tracking because the current technology has not been this advanced yet.

- *Misinformative*, which is false or out-of-context information that is intentionally or unintentionally presented as fact to deceive. For example, it is misinformative that the COVID-19 vaccines are mandatory because they are strongly recommended, but not mandatory.
- *Disinformative*, which is a type of misinformation that is intentionally delivered the false or misleading information to deceive or mislead readers. For example, it is disinformation that the COVID-19 vaccines were not properly tested or developed since they were tested legitimately.
- *Neutral*, which cannot be decided by the proposed method. For example, our method is not able to decide whether Coronavirus is from labs since even the societies have controversy about this in these days, let alone software.

The System Structure

Figure 1 shows the workflow of this research which takes the following steps:

1. Preprocessing the message consisting of the following four steps:
    a. Lexical analysis, which finds the keywords from the message,
    b. Stopword removal, which removes stopwords from the message,
    c. Stemming, which finds the stem of a word, and
    d. Synonym discovery, which finds similar keyword and group as one.
2. Indexing and storage, which save the processed messages in a database,
3. Testing (classification) by using four message similarity measurements consisting of
    a. Keyword matching,
    b. Phrase matching
    c. LCS matching, and
    d. LACS matching.
4. Data fusion function to combining all four similarity scores.

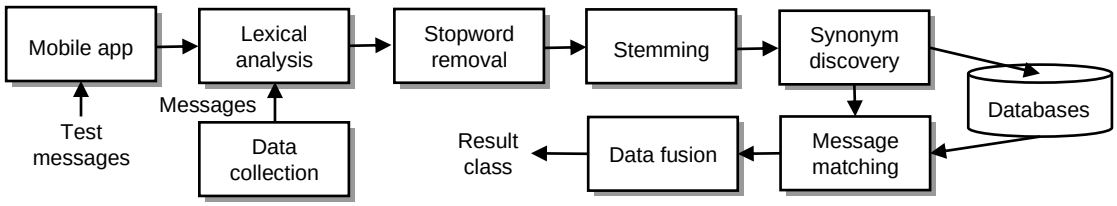


Figure 1. A Workflow of the Proposed System

The System Components

This part of the paper discusses various components of the proposed system except the four message matching methods, which will be detailed in the next section.

Lexical Analysis

Lexical analysis is the process of converting an input stream of characters into a stream of words or tokens, which are groups of characters with collective significance. It is the first stage of automatic indexing which is the process of algorithmically examining information items to generate lists of index terms. The lexical analysis phase produces candidate index terms that may be further processed, and eventually added to indexes. It also helps split the longer sentences into smaller chunks of the dataset to perform algorithms with better accuracy.

Stopword Removal

English stopwords such as is, has, an, the, etc. do not signify any importance as index terms when analyzing the dataset for information. It is crucial to remove the stopwords from the dataset as they do not help us find the true meaning of a sentence and can be removed without any negative consequences. Also, eliminating such words from consideration early in automatic indexing speeds processing, saves huge amounts of space in indexes. It has been recognized since the earliest days of information retrieval that many of the most frequently occurring words in English (like “the,” “of,” “and,” “to,” etc.) are worthless as index terms. A search using one of these terms is likely to retrieve almost every item in a database regardless of its relevance, so their discrimination value is low. Furthermore, these words make up a large fraction of the text of most documents: the ten most frequently occurring words in English typically account for 20 to 30 percent of the tokens in a document. Eliminating such words from consideration early in automatic indexing speeds processing, saves huge amounts of space in indexes, and does not damage retrieval effectiveness.

Stemming

It is a technique for improving retrieval effectiveness and reducing the size of indexing files is to provide searchers with ways of finding morphological variants of search terms. If, for example, a searcher enters the term stemming as part of a query, it is likely that he or she will also be interested in such variants as stemmed and stem. Since a single stem typically corresponds to several full terms, by storing stems instead of terms, compression factors of over 50 percent can be achieved. The stem need not be identical to the morphological root of the word; it is usually sufficient that related words map to the same stem, even if this stem is not in itself a valid root. It is a method for casting words into their original form which aims to the removal of inflectional endings from words. It performs morphological analysis on the words by returning the words into its dictionary meaning. For example, the stemming converts caring into care, troubled into trouble, geese into goose, etc.

Synonym Discovery

Many times, common terms like coronavirus, COVID-19, Omicron, and Delta virus could be treated the same while measuring the message similarity. Instead of building a thesaurus, which is not a trivial task, this research

stores synonyms of a set of popular words such as COVID-19, vaccine, and message in a database. The database is checked whenever a similarity measurement runs.

However, this approach is a temporary fix because it misses many words. Future research will consider taking advantage of online services like https://www.synonym.com/, which provides a list of synonyms of a word, but it slows down the execution tremendously. On the other hand, saving all synonyms in a database is not feasible since it would take much space from a database. More investigation needs to be conducted for this matter.

Message Similarity Measurements for Misinformation Detection

The measurements of message similarity will be used to classify the message as one of the five information classes (true, fake, misinformative, disinformative, and neutral). The following four similarity measurements are used in this research:

- (Keyword matching) Number of keywords matched,
- (Phrase matching) Phrases matched,
- (LCS matching) Longest common subsequence, and
- (LACS matching) Longest approximate common subsequence.

After the four similarity scores are found, the recommended class is generated by a data fusion function, which is the process of integrating the four measurement scores to produce more consistent, accurate, and useful information than that provided by any individual measurement. Figure 2 shows the data fusion function, of which the recommended class is found by the class of majority message. The system can be found at GitHub (E Vadakkethil Somanathan Pilla, n.d.).

DATA-FUSION *(messages* $m_{1\text{-}4}$*, classes* $c_{1\text{-}4}$ ***)***
Input: *four messages* $m_{1\text{-}4}$ *and their corresponding four classes* $c_{1\text{-}4}$
// The $m_{1\text{-}4}$ *are the messages with the highest similarity scores*
// from keyword, phrase, LCS, and LACS matchings, respectively.
Output: *the recommended class c*

1. ***if*** *three of the four messages* $m_{1\text{-}4}$ *are the same*
2. $c \leftarrow$ *the class of the three messages*
3. ***else if*** *two of the four messages are the same*
4. $c \leftarrow$ *the class of the two messages*
5. ***else*** $c \leftarrow c_4$
6. ***return****(c)*

Figure 2. The Algorithm of the Data Fusion Function Used by This Research

Number of Keywords Matched (Keyword Matching)

This is the simplest method used. It counts the number of keywords matched between the testing message and each of the saved messages in the database. The class of the testing message is the class of the saved message with the highest number of keywords matched. For example, the similarity score of the following two messages is five:

m_1: center disease control prevention introduce oral tablet covid-19 vaccine effective no side effect

m_2: mask social distance coronavirus covid-19 vaccine symptom disease control prevention

because there are five keywords (disease, control, prevention, covid-19, and vaccine) matched according to the following equation:

$$\text{similarity} = \#\text{ of keywords matched} \tag{1}$$

Phrases Matched (Phrase Matching)

Other than counting the number of keywords matched, this method also considers the number and length of the phrases matched by using the following equation:

$$\text{similarity} = (\#\text{ of keywords matched}) + 2\times(\#\text{ of phrases matched}) + \sum(\text{length of each phrase matched}) \tag{2}$$

The higher the similarity score is, the more resemblant the two messages are. The class of the testing message is the class of the saved message with the highest similarity scale. For example, the similarity score of the following two messages is 14:

m_1: center disease control prevention introduce oral tablet covid-19 vaccine effective no side effect

m_2: mask social distance coronavirus covid-19 vaccine symptom disease control prevention

because similarity = $5 + 2\times2 + 3 + 2 = 14$ where the keywords matched (disease, control, prevention, covid-19, and vaccine) is 5, the phrases matched ("disease control prevention" and "covid-19 vaccine) is 2, and the lengths of phrases matched are 3 and 2.

Longest Common Subsequence (LCS Matching)

Consider each message is a sequence of words. The LCS (longest common subsequence) used here is the longest common subsequence between two messages, where subsequence of a given sequence is a sequence that can be derived from the given sequence by deleting some or no elements without changing the order of the remaining elements (Cormen, Leiserson, Rivest, & Stein, 2009). For example, Figure 3 shows an LCS example LCS(m_1,m_2)="disease control prevention" whose similarity score is 3 according to the following equation:

similarity = # of connections (3)

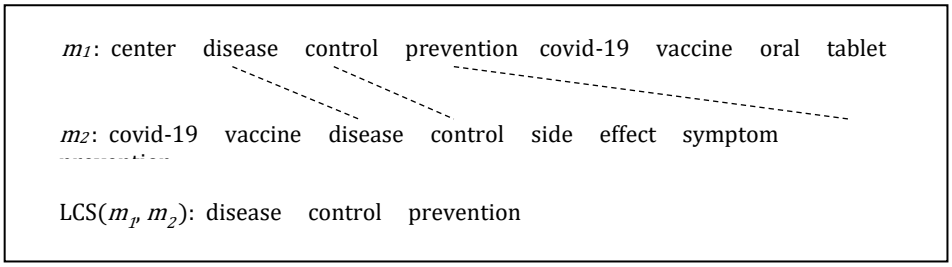


Figure 3. An Example of a Longest Common Subsequence Between Two Messages

Longest Approximate Common Subsequence (LACS)

However, the LCS method misses much information about the messages. For the example in Figure 4, the two messages s_1 and s_2 have five common words (covid-19, vaccine, disease, control, and prevention), but the LCS method only counts three words (disease, control, and prevention). The LACS method counts all five words, but has to take some weights from it like the following equation (Hu, Ritter, & Schmalz, 1998):

similarity = (# of connections) – (# of crossings)/(# of connections) (4)

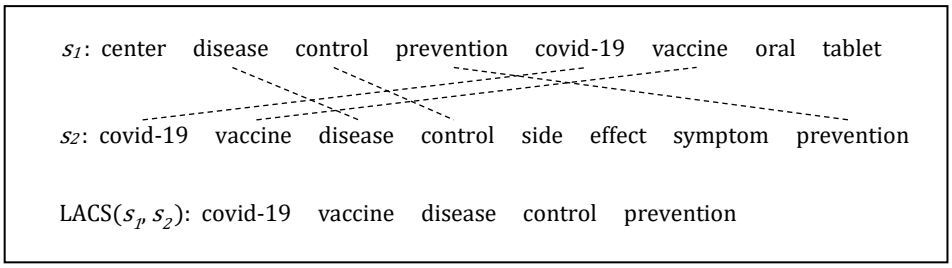


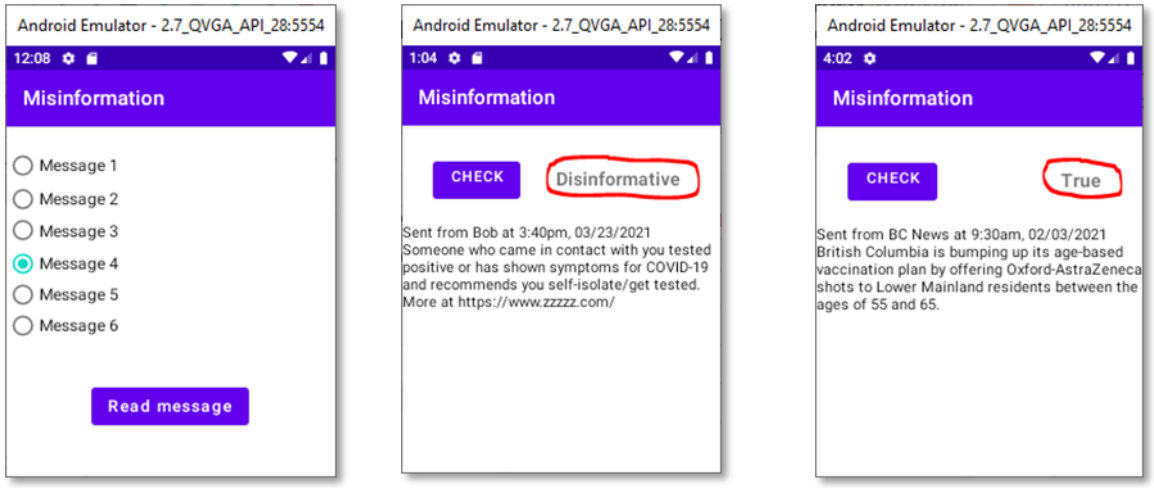
Figure 4. An Example of a Longest Approximate Common Subsequence Between Two Messages

Experiment Results

Experiment results are provided in this section to justify our research method. It includes two parts: the first part shows the experiment setup and results, and the second part gives the evaluation data and discussions.

Experiments

A prototype system is built to validate the proposed method. Xamarin (n.d.), a cross-platform app development platform, helps to build a single app for all devices. Figure 5 shows three screen shots from the experiment, where 5.a gives a list of text messages to check, a disinformative message is found in 5.b, and a true message is shown in 5.c.



(a) (b) (c)

Figure 5. The Screen Shots from the Experiments: (a) Selecting Which Message to Check, (b) Showing the Message and Its Class, and (c) Showing Another Message

Evaluations and Discussions

The experiment was described in the previous sub-section, and this sub-section gives and discusses the evaluation data. From the Table 1, the LACS matching performs the best and the keyword matching comes next. The LCS matching performs better than the phrase matching when the number of messages is less around 50. After that, the phrase matching beats the LCS matching. The experiment data is displayed in Table 1.

The results are expected like the LACS matching having the highest accuracy, but it also shows some surprising findings like the accuracy of keyword matching being higher the ones of the phrase and LCS matchings. Identifying misinformation is intrinsically difficult. People are not able to tell whether the information is correct easily, let alone computers. The following observations are noticed:

- The accuracy is satisfactory because of greater than the threshold value 50%, but not optimal. It may be because the information provided by short messages is limited. To fix the problem, more information or knowledge needs to be discovered from the messages.
- The LACS method is supposed to beat other three methods because it considers more features in messages. The experiment data also supports the assumption.
- It is surprising to find that the accuracies of true messages are the lowest and the ones of fake messages are the highest. It may be because the vocabulary of true messages is broad and the one of fake messages is limited, so finding fake messages is easier.
- The evaluation data may be bias because the messages are filtered beforehand and may not be generic enough. To be fair, the proposed method should be compared to other methods.

Table 1. Experiment Data of the Four Message Similarity Measurements

	True	Fake	Misinformative	Disinformative	Neutral	**Overall Accuracy**
Keyword	11/24=46%	49/52=94%	24/35=69%	26/34=76%	26/44=59%	136/189=72%
Phrase	10/24=42%	46/52=88%	20/35=57%	23/34=68%	25/44=57%	124/189=66%
LCS	09/24=38%	43/52=83%	17/35=49%	18/34=53%	28/44=64%	115/189=61%
LACS	10/24=42%	50/52=96%	23/35=66%	27/34=79%	31/44=70%	141/189=75%

Conclusion

Smartphones are indispensable devices for people in these days, and tens or even hundreds of messages are sent to each device every day. All kinds of information can be found from the delivered messages such as news, greetings from family members or friends, advertisements, promotions, weather reports, etc. People are overwhelmed by the sheer amount of information, and they spend much time trying to find a way to sort out the messages. Even worse is some messages give false or fake information and mislead the viewers consequently. The problem becomes more serious especially during the pandemic. This research tries to automatically classify the mobile health messages into one of the five classes: true, fake, misinformative, disinformative, and neutral by using various mobile information retrieval technologies, which include text preprocessing (consisting of lexical analysis, stopword elimination, stemming, and synonym discovery), indexing and storage using a database, message similarity measurements (consisting of keyword, phrase, LCS, and LACS matching), and data fusion. Experiment results show the proposed method is effective, but it still has room for improvement. This paper not only gives innovative and practical methods for misinformation detection, but also provides great pedagogic values for readers who are interested in learning various information retrieval methods and misinformation research.

Future Research Directions

Experiment results show the proposed method works. However, there is still room for improvement. Using RNN (recurrent neural network) to handle the sequential data will be considered next. The ANNs (artificial neural networks) can also be considered because this problem has no definite answers. For example, a message may be considered true for some people, but others may think it is disinformative, especially if it is related to politics, and ANN is competent for this kind of ambivalence. However, DL (deep learning) will not be considered because the information provided by short messages is limited and DL is good at processing complicated and large data sets like images and speeches. In addition, other than using artificial neural networks to detect misinformation, statistical means will be considered too. The statistical means includes the methods of Bayesian classifiers and hidden Markov models. It is less innovative but may be more effective. On the other end, this problem, mobile health misinformation identification, could be classified as one of the NLP (natural language processing) problems. We will consider a variety of NLP methods and adapt them to our problem and see whether the problems are mitigated. Besides, there has been a rising interest in proactive intervention

strategies to counter the spread of misinformation and its impact on society. Methods to mitigate the ill effects caused by misinformation will be investigated too.

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Education 4.0 and Its Reflections on the Turkish Education System

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Abstract: With the emergence of Industry 4.0, change has accelerated in the field of education, as in many other fields. With the artificial intelligence applications developed within the scope of Education 4.0, expert systems, intelligent instructional systems, and dialog-based instructional systems have started to be used. This research aims to evaluate Education 4.0 and the existing applications in the Turkish Education System together. The theoretical framework of the new understanding that comes with Education 4.0 has been introduced. Students must be equipped with 21st-century skills to adapt to the changing world. Providing students with learning and innovation skills, knowledge, media and technology skills, and life and career skills is essential. Critical thinking, creativity, and problem-solving are core skills. It can be said that the current opportunities in Türkiye are at a level that can form the basis for education 4.0. The existing infrastructure needs to be developed for new applications to be carried out healthily. In order to develop a shared understanding in practice, awareness levels of teachers, administrators, parents, and students should be increased, and long and short-term plans should be developed.

Keywords: Education 4.0, 21st-Century Skills, Turkish Education System

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Introduction

The industrialization process, which started in Europe, is progressing by showing continuous development. Each industrial revolution combined the scientific and technological developments of previous revolutions, and cumulative progress was made. While the replacement of body power by machines has been discussed recently, today, industry 4.0 and expanding the usage areas of robots and artificial intelligence are discussed.

Industry 4.0 is planned to change the structure of production systems, and it is aimed that fewer and more qualified individuals follow the work. Production errors are reduced in industry and factories, and the quality of the goods produced increases. The world population is increasing day by day. However, it is predicted that the need for a workforce will decrease with Industry 4.0. It is foreseen that problems such as unemployment may increase, and income distribution may deteriorate if new business lines and service areas cannot be created. In terms of socioeconomic sustainability in the world, developing countries need to take the necessary steps for

Industry 4.0.

The rapid developments in the field of digitalization, the processing of big data, and the importance of the concept of the internet of things have led to the emergence of the fourth industrial revolution (Soylu, 2017). Production and marketing focused on speed, efficiency, cost, and innovation form the basis of the fourth industry cycle. The primary purpose of the fourth industrial revolution is to keep in touch with all the units involved in the production process, to access the big data needed, and ultimately to produce the products and services that best meet expectations. Industry 4.0 considers the technological developments before it, considers current needs, and paves the way for taking steps for the future.

Today, countries are developing many strategies to be at the forefront of technological development and competition. One of these strategies is to understand the concept of industry 4.0 and take steps accordingly. In this way, it is tried to increase the interaction between industrial products and information technologies. It is aimed to disseminate new generation software, hardware, and smart systems. By establishing smart factories, class error is targeted in the production processes, and it is planned to use robots and artificial intelligence instead of body power (Bayburt & Eğin, 2021). One of the essential advantages of this situation is the increase in individual comfort. In this way, individuals can allocate more time to their social lives, work less and lead a more comfortable life.

Industry 4.0 should not be perceived only as digitalization and new technological equipment. The fourth industrial era, which has a multifaceted structure, has started to cause significant changes in many sectors and social areas. One of the sectors affected by the fourth industrial revolution was education. Education and industrial revolutions interact. Developments in education lead to industrial revolutions (Saykılı, 2018; Wannapiroon et al., 2021). Applications developed through education reach large audiences. Through education, new applications, knowledge, and skills can be gained quickly. The breakthroughs made by countries in the field of industry are closely related to the quality of their education systems. Scientific research leads to the development of new technologies. The values, approaches, and benefits that emerge with these technologies are transferred to the younger generations through the education system.

Education 4.0

With the emergence of Industry 4.0, change has accelerated in many areas. One of these areas is education. The fact that the production is carried out entirely by machines causes a decrease in the human labor force to perform the production. The human workforce that will fix the malfunctions of the machines and do their maintenance comes to the fore. The education system has to train the human working day that the industry needs. In this way, the needs and expectations of society can be met. Developments in education and industry move together. The education system has been revised over time according to changing needs. Such revision needs transformation of education and the shift from traditional methods to technology-enhanced active learning environments including participatory teaching methods such as peer learning, student-centered method, peer

collaboration and argumentation (Latifi & Noroozi, 2021; Latifi et al., 2020, 2021; Noroozi 2018, 2022; Noroozi et al., 2012; 2016; 2020; Valero Haro et al., 2019; 2022).

With the realization of the industrial revolution, the need for people who would literally fulfill the commands given in the factories arose. The aim of the education system (Education 1.0) in this time period was to provide the needed workforce. The source of information was determined as the teacher and the generally accepted information was transferred to the students with a rote understanding. With Education 2.0, an understanding that the school is considered a factory and the students as a product of these factories has prevailed. Again, in this period, an educational approach towards the development of technological tools needed by the industry was adopted. Recently, with the development of information technologies, the concept of self-learning has been introduced (Öztemel, 2018). Access to information has become very fast and easy. Knowing what information is needed to develop a product or service has become more critical. The importance of selecting and using information and producing new information is increasing daily.

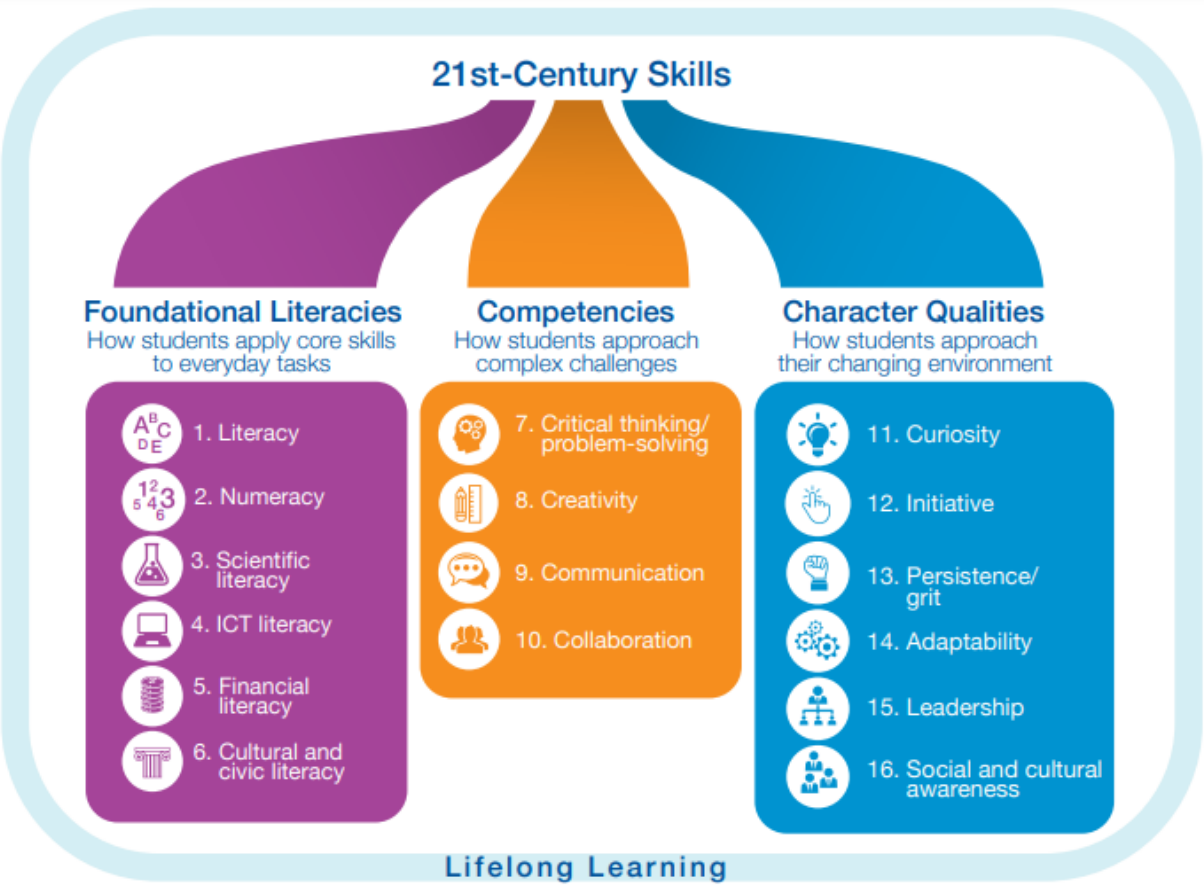

Figure 1. Students Require Basic Skills for the 21st century (World Economic Forum, 2016, p. 4)

In today's industry, smart production systems are replacing standard systems. Accordingly, the needs for production in factories change. One of the changing needs is a workforce. Education systems continue to make radical transformations to meet new needs. In this way, it aims to prepare students for the future, equip them with different skills, and be ready for business life. It is considered essential to provide students with basic skills

known as 21st-century skills. There are different views on what this skill is. The World Economic Forum has grouped these skills under the heading of "lifelong learning" as basic literacy, competencies, and character traits. Basic literacy skills include core skills for performing daily tasks. Competencies represent the skills required to complete more complex tasks outside of daily tasks. On the other hand, character traits are related to the skills necessary to adapt to the changing environment (World Economic Forum, 2016).

When Figure 1 is examined, literacy, numeracy, scientific literacy, ICT literacy, and cultural and civic literacy are among the essential competencies. Core competencies include critical thinking, problem solving, creativity, communication, and collaboration. It is aimed that students gain character traits such as Curiosity, initiative, persistence/grit, adaptability, leadership, and social and cultural awareness (World Economic Forum, 2016). The basic skills that need to be taught within the scope of the "Partnership for 21st Century Skills" project are discussed (Partnership For 21st Century Skills, 2009). The skills that students should acquire are listed under the themes of "Learning and Innovation Skills, Information, Media and Technology Skills, Life and Career Skills." Critical thinking, creativity, and problem-solving were emphasized (Ozturk, 2023; Voogt & Roblin, 2012).

The literature emphasizes that coding education is vital in terms of gaining students' logical and reasoning skills (Gültepe, 2018). Coding training can be used as a tool to gain 21st-century skills. Coding pieces of training can be equipped with essential skills, and young individuals can be given the ability to develop products. Coding is a language that enables individuals to communicate with information technologies. Through this language, step-by-step instructions can be made by computers. The orientation of technological tools to meet individual needs has become essential to daily life. In addition, available information is becoming more and more complex every day. The rapid change in knowledge structure causes societies to change and develop rapidly. Coding prepares individuals for life by giving them essential skills such as creative thinking, problem-solving, critical thinking, analytical thinking, and systematic thinking. The young generations must start life successfully to meet society's needs and expectations.

14 basic teaching strategies have been developed to develop social, cognitive, and emotional skills (World Economic Forum, 2016). Creating appropriate learning environments and applying these strategies in the classroom can contribute to the multifaceted development of students. These strategies are listed as follows; Encourage play-based learning, break down learning into smaller, coordinated pieces, create a safe environment for learning, develop a growth mindset, foster nurturing relationships, allow time to focus, foster reflective reasoning and analysis, and offer appropriate praise, guide a child's discovery of topics, help children take advantage of their personality and strengths, provide appropriate challenges, offer engaged caregiving, provide clear learning objectives targeting explicit skills, use a hands-on approach (Figure 2). Especially early childhood period is a critical period for gaining social, cognitive, and emotional skills. This period can facilitate teaching the subjects through gamification, including open-ended questions, supporting creative thinking and interaction, and achieving desired results in a safe learning environment.

Another recommended teaching approach to contribute to the versatile development of students is the "growth mindset" (Dweck, 2016). It is believed that intelligence and abilities can be developed in classrooms where this

approach is adopted and applied. The understanding is adopted that the brain can be strengthened by the practice and hard work like a muscle. It has been argued that this approach positively affects academic motivation and performance. In addition, it has been stated that this approach facilitates the creation of learning environments that encourage them to face challenges, discover new things and learn from their mistakes.

With the development of technology, artificial intelligence applications have started to become widespread. Every comment we write on the internet, every web page we click, and every form we fill out becomes a part of a large data set. Platforms such as social media collect user information and create "big data." Artificial intelligence algorithms predict users' attitudes, behaviors, and preferences by applying large data sets. Artificial intelligence and big data also offer an excellent opportunity for the individualization of education. By analyzing the individual data of the students, their strengths and weaknesses can be determined. The learning process can be sustained at its own pace, taking into account the personal needs of each student. The necessary information can be obtained for the preparation of learning environments suitable for students' learning styles and interests. In addition, by analyzing personal data, guidance services can be maintained more qualified, and personal assistants can be programmed more effectively.

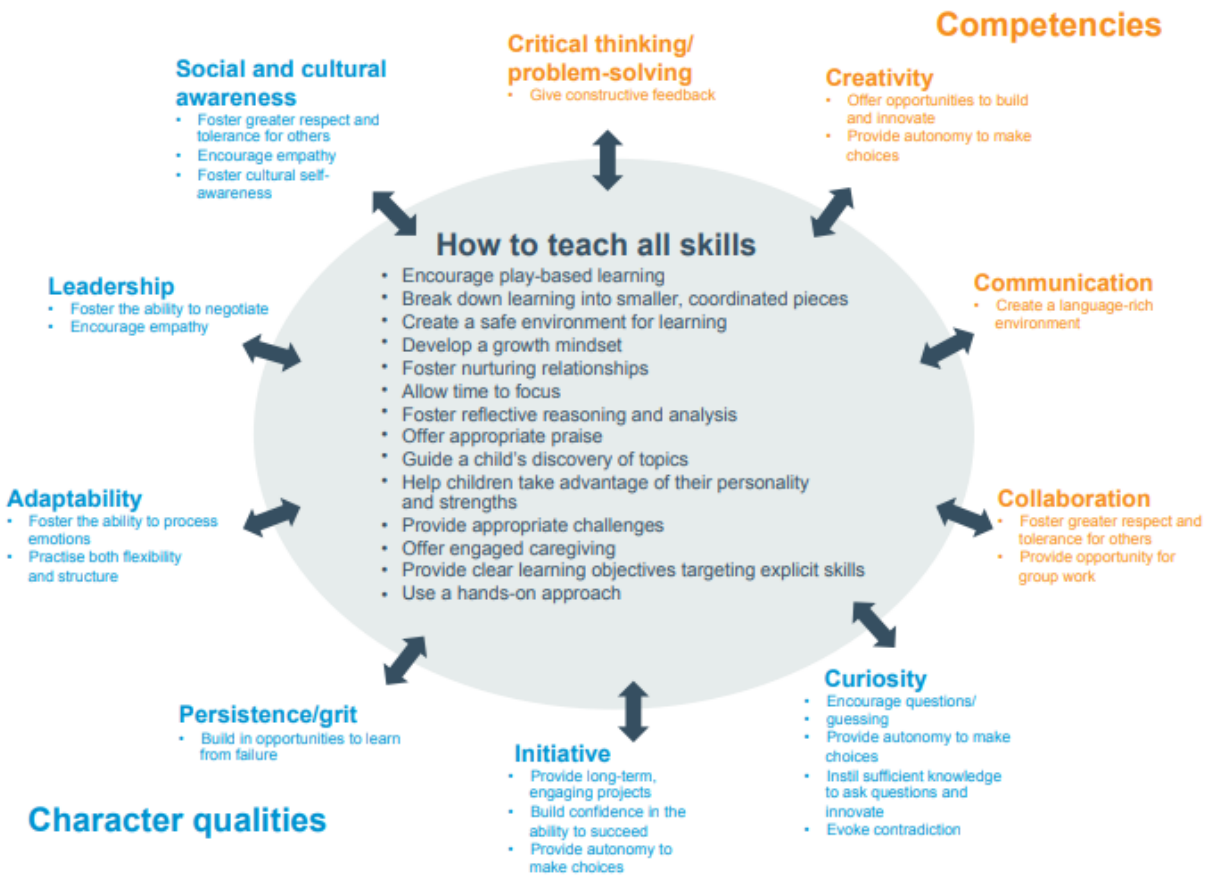

Figure 2. A Variety of General and Targeted Learning Strategies Foster Social and Emotional Skills (World Economic Forum, 2016, p. 8)

It is possible to examine artificial intelligence applications developed within the scope of Education 4.0 under three headings: expert systems, intelligent instructional systems, and dialog-based instructional systems (Arslan,

2020). Expert systems refer to the realization of the work of an expert using artificial intelligence. The main purpose of these systems is to answer questions related to a specific field of expertise with artificial intelligence applications. It is aimed to prepare personalized education programs for students with intelligent instructional systems. Topics progress according to the speed and level of the learner. Learning experiences are planned step by step, taking into account the characteristics of the individual. Appropriate feedback is provided by evaluating student responses with dialog-based instructional systems. In this way, the student's deficiencies are determined in detail, and he learns better. In order to individualize education and respond to varying needs, the systems developed within the scope of Education 4.0 should be implemented. Significant transformations are required to integrate these systems into education. The speed of these transformations depends on investments in education and a qualified workforce. The rate at which they are provided can determine the place of countries in the technology race.

Practices in Türkiye Related to Education 4.0

The acceleration of change in every field makes the future uncertain and ambiguous. In this case, it is necessary to use new techniques and change curricula in order to prepare students for the future. Able to adapt to change quickly and agilely; the necessity of gaining skills to cope with uncertain, complex, and ambiguous situations has revealed 21st-century skills.

A competency-based education model can be adopted for students to gain 21st-century skills effectively. By defining specific competencies and skills, competency-based learning can be stepped in. It is aimed that students to master and specialize in the defined competencies. Mastery, expertise, in-depth study, learning agility, and skill development are essential concepts associated with competency-based training. Curriculums prepared in Türkiye in 2018 also adopted the concept of competency-based education. Curriculums are structured by considering knowledge, skills, and values. Each curriculum aims to provide students with essential life and course-specific skills. For example, the mathematics curriculum, besides knowledge and skills related to mathematics, it is aimed to gain competencies such as communication in the mother tongue, communication in foreign languages, digital competence, learning to learn, taking the initiative and entrepreneurship, cultural awareness, and expression (MoNE, 2018). However, in all curricula, justice, friendship, honesty, self-control, patience, respect, love, responsibility, patriotism, and benevolence are specified as "root values," and it is aimed to gain these to students. The changes made in the curriculum show parallelism to the developments observed in the field of education in the world. However, there are critical deficiencies in the ways to gain the skills, competencies, and values specified in the program and in the structures to evaluate them (Konca, 2020). Teachers and administrators have significant responsibilities for the effective implementation and evaluation of the programs. Teachers need to be motivated and constantly search for students to gain knowledge and skills in the program.

Design and skills workshops can also create suitable environments for students to acquire 21st-century skills. Production workshops aim to enable students to use new generation design and production technologies, hand skills, and coding together. In these workshops, teachers are expected to guide students. The fact that teachers

are equipped and competent in teaching skills can increase the quality of the education provided. Design and skill workshops are defined in the Education Vision Document of the Ministry of National Education. It is planned to be established for a common purpose at primary, secondary, and high school levels. The contents are associated with occupations and based on manual skills. It is planned to reduce the compulsory course hours and course diversity. It is aimed that students can deepen the basic lessons, make personalization and perform practice-based activities. It can be said that teacher training and pilot studies for the already mentioned workshops are suitable for the 21st-century learning framework. The increase in production workshops and practice-based courses in schools can enable students to gain high-level skills in a cognitive, affective, and psychomotor sense.

The Flipped Classroom model has been recommended to improve the quality of teaching in different courses (Bhagat et al., 2016; Chen et al., 2018; Kesharwani & Kesharwani, 2022; Ouiam & Abdelkader, 2022). In this model, students obtain information about the course through out-of-class practices. He tries to grasp the subjects with his own effort by participating in out-of-class practices. Performs activities that support the subjects by participating in classroom practices. He tries to reinforce the topics with the help of the teacher. With the pandemic process in our country, the Ministry of National Education has made significant investments in distance education. In this process, Education Information Network (EBA) was used effectively. Based on the Flipped Classroom model in the lessons, students can learn the subjects outside the classroom at any time and place via EBA. In this way, students can have the opportunity to deepen their knowledge about the subjects under the guidance of the teacher in the classroom. More time can be devoted to discussion activities in the classroom. Students can have more time to develop high-level thinking skills such as critical, creative, analytical, and reflective thinking.

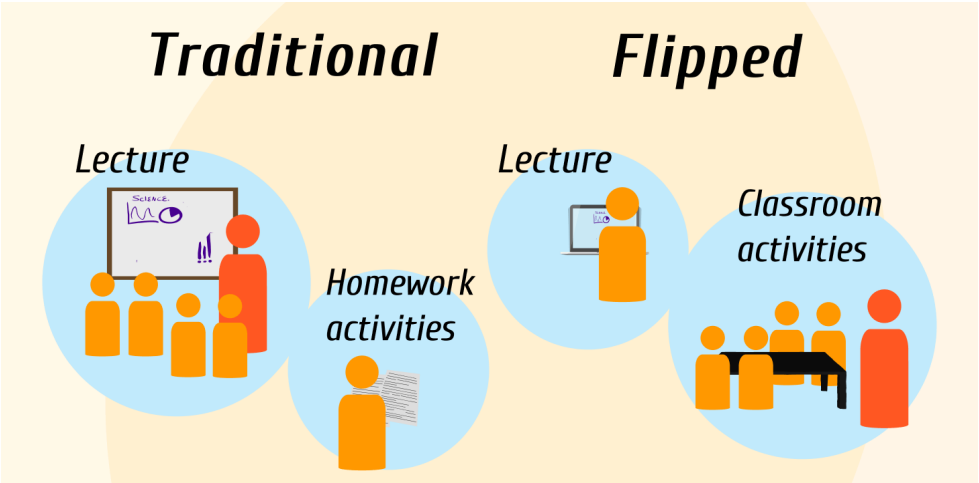

Figure 3. Traditional Instruction Versus the Flipped Classroom (www.blendspace.com)

STEM; refers to the interdisciplinary approach that expresses the use of Science, Technology, Engineering, and Mathematics together. STEM makes more sense than the disciplines it encompasses. Other disciplines, such as history, art, language, and geometry, can also be included in the STEM application process. STEM is an

experiential learning path for children to play and design while learning. STEM applications support critical thinking, creative thinking, and problem-solving skills. In our fast-paced and technology-oriented world, favorable environments can be created for children. It is observed that there are misconceptions about the STEM approach. Coding and robotic coding can be considered STEM applications in applications in which only technology is used. STEM applications need to be scenario-based and inquiry-based. Today, discussions continue about integrating the STEM approach into the curriculum. The Ministry of National Education has published the book "Aiming Outcome-centered STEM Practices" for pre-school and primary schools. This book includes examples of themes, scenarios, activities, and plans related to STEM applications. Developing exemplary practices at the high school level can guide teachers in establishing interdisciplinary interaction. The STEM approach has the potential to bring together science, mathematics, technology, and art. STEM applications can be an essential tool in gaining 21st-century skills for students.

Augmented virtual reality can make the learning environment more authentic and immersive (Abdusselam & Kilis, 2021; Aimiuwu, 2022; Alper et al., 2021; Johnson & Westbrooks, 2021; Kozcu Cakir, Guven, & Celik, 2021; Talan, 2021; Talan & Kalınkara, 2022; Tas & Bolat, 2022). Students can gain lifelike experiences by participating in virtual reality applications. By supporting students' exploration skills, they can participate in virtual experiments and go on trips. Substantial opportunities can be offered for students to be more active in the teaching process and to acquire permanent learning (Liu et al., 2020). In this way, students can go beyond traditional textbooks and videos and explore objects and shapes more closely. Thanks to virtual reality tools, it is possible for students to travel anywhere in the world and discover places they are curious. With many free applications, augmented and virtual reality applications can be used in the classroom. Teachers' knowledge of these practices, their examination, and inclusion in their teaching plans can contribute to creating an effective learning environment. For virtual reality applications, it may be helpful to examine the "Nearpod," "Google Expeditions," and "Google Tour Builder" applications.

Conclusion

Within the scope of Education 4.0, many approaches and practices help students gain 21st-century skills. It can be said that the current opportunities in Türkiye are at a level that can form the basis for education 4.0. For new applications to be carried out healthily, the existing infrastructure needs to be developed. Awareness levels of teachers, administrators, parents, and students should be increased, and long and short-term plans should be developed in order to create a shared understanding in practice. Large-scale projects are needed for the technology-supported transformation of learning environments. Teachers need in-service training to develop, use and integrate technology-supported enriched classroom applications into their plans.

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Factor Analysis of the Educational Development Level of 31 Provinces in China

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Abstract: This paper selected the 11 indices of measurable factors, which affect the level of education development in China, and uses the statistical methods of factor analysis to extract the four common factors. Then the research conducts a comprehensive evaluation of the education development level of 31 provinces in China. Finally, the author uses cluster analysis to integrate the research findings into Chinese undergraduate students' informative needs for gaining further references about choosing their universities for graduate schools in variant parts of China.

Keywords: China's higher education, factor analysis, educational development level, regional gap

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Introduction

The most competitive resource in the 21st century is human resources. China is facing the critical task of building a well-off society in an all-around blueprint and the historical mission of the great rejuvenation of the national transformative construction. Talent is the most necessary condition to accomplish these ambitious goals, and the generation of talents mainly depends on education. China is a country with the largest population in the world, and it is a long way to go in running education well. No matter the education authorities, teachers, students, and parents all have responsibilities that cannot be ignored.

Since the initiative was launched from the Universal Declaration of Human Rights in 1948, the right to education has been mutually recognized worldwide and governments commonly started to take on their moral obligation to implement it (Kamanzi, Goastellec & Pelletier, 2021). Thus, the continuous empowerment of equal higher education has also become an indispensable constituent of justice and social cohesion (Akman, Karaaslan, & Bayram, 2022; Brennan & Naidoo, 2008; Goastellec, 2008; Ozturk & Ozturk, 2022; Post et al., 2022).

In accordance with the global trend, Chinese higher education reform is supposed to take ensuring both equity and efficiency as priorities in all the provinces. The development of education is an important task in China, and

the basic situation of China's current education is that primary education is basically universal, but in backward areas, such as western regions, especially Tibet and ethnic minority areas, the investment in education, people's awareness of education and the quality of teacher education are still unsatisfactory. The empirical findings attained by Borsi, Mendoza, & Comim (2022) indicate an apparent and persistent heterogeneity in the higher education resources between provinces in China, reflecting the quantity- and quality-related provincial gaps in China's higher education system, just like the uneven distribution number of universities among provinces, which could determine the enrollment and attainment levels, which could be regarded as the most reliable indicator for the supply of higher education in China. Consequently, given China's huge population and wide territory, it is of great necessity to verify whether the multitude of educational reforms and the founding of state-funded world-class universities in different provinces could explain inequalities according to education and human development in China (Borsi, Mendoza, & Comim, 2022).

Besides, since increases purely in the number of universities could positively affect economic growth and regional development (Valero & Reenen, 2019), the imbalances among provinces might be due to the unevenly low or high provision of quality tertiary education (Borsi, Mendoza, & Comim, 2022; Maddah, 2021). Arguably, the foci of this research follow a significant implication of former research implying that in higher education, both the analysis regarding quantity and quality should be taken into account when evaluating the distribution of higher education resources.

Researchers (Benos & Zotou, 2014; Zhong, 2011). Notably, Borsi, Mendoza, & Comim (2022) find that both the quantity and quality of the provision of higher education in China are provincially imbalanced, despite in the past decades, the educational reforms have continuously underpinned the equalizing educational policies and higher education expansion via massification enhancement. Moreover, despite the rocketing emergence of private HEIs, the market-oriented educational reforms have not particularly favored the relatively less-developed Central and Western provinces in China (Borsi, Mendoza, & Comim, 2022). Thus, there is an urgent need to embark on the regional higher education agenda reforms distinctively in terms of the research references about assessing the competitiveness of each province's higher education

Moreover, higher education is faced with more contradictions, such as the backward social and economic development of the region cannot meet the basic needs of providing quality higher education for the mass, the disadvantaged regions' lack of access to higher education, the public's awareness of pursuing higher education in less-developed areas is relatively weak, and the basic education at K-12 stage is generally not enough, especially in the countryside. The development gap between urban and rural areas is huge, and the phenomenon of low teaching quality in rural areas emerges broadly.

Furthermore, the imbalanced development as illustrated above among different regions in China brings about a huge gap in college-entrance examination performance in eastern, middle, and western China. Just as Table 1 shows, variant regional socioeconomic factors lead to uneven education outcomes. The students in central and western provinces have difficulty being admitted to top-tier universities.

Table 1. The College Entrance Examination Admission Rate in different regions in China

Region	College Entrance Examination Admission Rate				
	Year 2010	Year 2013	Year 2016	Year 2018	Year 2020
Eastern	79.26%	82%%	88.8%%	85.55%	89.58%%
Central	70.9%%	79%%	90.75%	85.10%	86.27%
Western	69.09%	77%%	83.72%%	83.72%	85.72%

From the above table, it can be found that the college entrance examination admission rate has increased year by year, indicating that high school education has been greatly developed in recent ten years, and more students can enter colleges and universities for further study. However, there are still huge gaps in the admission rate of colleges and universities in the East, central and western regions. The admission rate in the East and central regions is significantly higher than that in the West. Also, a huge gap obviously exists in quality high school resources between advanced eastern China and the less developed middle and western parts. The quality of high school education is directly related to the performance of the college entrance examination.

Table 2. The Distribution of the Top 100 High-level Middle Schools in China

Region	**Eastern**	**Central**	**Western**
Number of "Top 100 Middle Schools"	**50**	**32**	**18**

Just as Table 2 illustrates, the top 100 high-level middle schools in China are distributed unevenly, with 50 in the east, 32 in the central, and 18 in the west.

In order to improve the status quo of educational inequality in China, it is necessary to understand its influencing factors. In this paper, starting from the supposed factors that may affect education in China, using factor analysis and cluster analysis method, the researcher lists the 11 indices that may influence the education development level index, and the factor analysis method to the dimension of the index number in order to find out the major influencing factors on the local education.

It also aims to provide some help for improving the direction of education reform and puts forward several suggestions for developing education according to each factor. Then, according to the contribution rate of the factor, the comprehensive score and ranking of the education development level of 31 provinces in China are

calculated, and a detailed analysis of typical provinces is carried out to realize the status quo of the education development level in China systematically and comprehensively.

Through literature review and integration, 11 factors affecting the educational development level of a certain region are summarized as follows:

X_1: GDP

X_2: Number of colleges and universities

X_3: Income gap between urban and rural residents

X_4: Number of historical and cultural sites

X_5: Number of population flows (mostly rural population entering the city)

X_6: Number of college students

X_7: Amount of university funds

X_8: Local industrial structure

X_9: Local traditional educational concept

X_{10}: Number of full-time teachers in Colleges and Universities

X_{11}: Urban and rural education system

Two Theories of Factor Analysis

Statistical Definition

In the research of social, political, economic, and medical fields, it is often necessary to conduct a large number of observations on multiple variables reflecting significant factors, and collect a large number of data for finding rules. In most research, the correlation between various variables would be found with this quantitative method. Therefore, it is possible to use comprehensive indicators to analyze complicated information existing in various variables, while the comprehensive indicators are unrelated to each other, and the comprehensive indicators that represent multiple information are called factors. These factors can be considered as new and simplified variables that retain considerable information from the original variables. Each factor implies the combination of the original variables and often represents a few basic factors that play a decisive role in the original problem. Therefore, factors can reproduce the correlation between original variables and reveal the internal causes of these relations, which boosts the exploration of the cause and effect.

Characteristics of factor analysis:

(1) The number of factor variables is far less than the number of original indicator variables.

(2) The factor variable is not a selection of the original variables, but a reconstruction based on the information of the original variables, which can reflect most of the information of the original variables. There is no linear relationship between factor variables, so it is convenient to analyze variables.

(3) The factor variable is nomenclature explanatory, that is, the variable is the synthesis and reflection of certain original variables' information.

Mathematical Model of Factor Analysis

The starting point of factor analysis is to replace most of the information of the original variables with fewer independent factor variables. It can be represented by the following mathematical model:

$$\begin{cases} x_1 = a_{11}F_1 + a_{12}F_2 + \cdots + a_{1m}F_m + a_1\varepsilon_1 \\ x_2 = a_{21}F_1 + a_{22}F_2 + \cdots + a_{2m}F_m + a_2\varepsilon_2 \\ \cdots \\ x_p = a_{p1}F_1 + a_{p2}F_2 + \cdots + a_{pm}F_m + a_p\varepsilon_p \end{cases}$$

Where are P original variables, standardized variables with the mean value of 0 and variance of 1, $x_1, x_2, \cdots x_p$ $x_i = (x_{1i}, x_{2i}, \cdots, x_{ni})' i = 1, 2, \cdots, p$. The representation matrix is in the form of : $X = AF + a\varepsilon$ where F are factor variables or common factors, which can be understood as mutually perpendicular m coordinate axes in high-dimensional space. And to meet:

1) $m < p$;

2) $Cov(F, \varepsilon) = 0$, F and ε are irrelevant;

3) $D(F) = \begin{pmatrix} 1 & & 0 \\ & \ddots & \\ 0 & & 1 \end{pmatrix} = I_m$, $D(\varepsilon) = \begin{pmatrix} \sigma_1^2 & & 0 \\ & \ddots & \\ 0 & & \sigma_p^2 \end{pmatrix}$ where $x = (x_1, \cdots, x_p)'$ is the p dimensional random vector composed of p measurable indicators, and $F = (F_1, \cdots, F_m)'$ is an unobservable vector. A is the factor load matrix, and a_{ij} is the factor load, which is the number j load of the number i original variable. If a variable x_i is regarded as a vector in the m - dimensional factor space, then a_{ij} would be the projection of x_i on the coordinate axis F_j, equivalent to the standard regression coefficient in multiple regression. ε is a special factor, representing the part of the original variable that cannot be explained by the factor variable, which is equivalent to the residual in multiple regression analysis. Several concepts in factor analysis are explained as follows:

Factor Load

In the case that each factor variable is unrelated, the factor load a_{ij} is the correlation coefficient between the number i original variable and the number j factor variable, that is, the relative importance of x_i at the number j common factor variable. Therefore, the greater the absolute value of a_{ij}, the stronger the relationship between the common factor F_j and the original variable x_i.

Degree of Commonality of Variables

The common degree of variables, also known as common variance, reflects the proportion of all common

factors explaining the total variance of the original variable. The common degree of the original variables is the sum of squares of the elements in the first row of the factor load matrix, that is, x_i A i $h_i^2 = \sum_{j=1}^{m} a_{ij}^2$ $Var(x_i) = h_i^2 + \sigma_i^2$ $i = 1,2,\cdots,p$

Thus, the variance of the original variable can be expressed as two parts: h_i^2 and σ_i^2. The first part h_i^2 reflects the proportion of variance explanation of the original variable by the common factor, and the second part σ_i^2 reflects the part of variance of the original variable that cannot be represented by the common factor. Therefore, the closer the first part h_i^2 is to 1 (the total variance is 1 under the premise of the standardization of the original variable x_i), the more information of the original variable is explained by the common factor, and how much information of the variable is lost can be learned through this value. If most of the common degree is higher than 0.8, the analysis is excellent. It can be said that the common degree of each variable is an indicator to measure the effect of factor analysis.

Variance Contribution of Common Factor F_j

The variance contribution of the common factor F_j is defined as the sum of squares of the elements in the j column of the factor load matrix A, that is $S_j^2 = \sum_{i=1}^{p} a_{ij}^2$, the variance contribution of the common factor F_j reflects the explanatory ability of the factor to the total variance of all original variables, and the higher its value is, the higher the importance of the factor is.

The Four Basic Steps of Factor Analysis

Factor analysis has two core problems. The first is how to construct factor variables, and the second is how to name and explain factor variables.

Factor analysis has the following four steps:

(1) Determine whether the original variables to be analyzed are suitable for factor analysis.

(2) Construct factor variables.

(3) Rotation is used to make factor variables more interpretable.

(4) Calculate the score of factor variables.

The following sections introduce the four steps respectively.

Determine the Original Variables' Suitability for Factor Analysis

Factor analysis is to construct a few representative factor variables from numerous original variables, which has a potential requirement, that is, the original variables should have a relatively strong correlation. If there is no strong correlation between the original variables, it is impossible to synthesize a few factors that can reflect the commonality of some variables. Therefore, in factor analysis, correlation analysis of the original variables is needed.

The simplest method is to calculate the correlation coefficient matrix between variables. If most of the correlation coefficients in the correlation coefficient matrix are less than 0.3 in the statistical test and fail the statistical test, then these variables are not suitable for factor analysis.

In the process of factor analysis, SPSS software provides several test methods to judge whether variables are suitable for factor analysis. The following two methods are mainly introduced.

Bartlett Test of Sphericity

Bartlett Test of Sphericity is based on the correlation coefficient matrix of variables. The null hypothesis correlation matrix is an identity matrix, and the Bartlett sphericity test statistics are derived from the determinant of the correlation coefficient matrix. If the value is large, and its corresponding concomitant probability value is less than the correlation between the original variables, it is suitable for factor analysis, and vice versa.

KMO (Kaiser-Meyer-Olkin) test

KMO statistics are used to compare simple correlation and partial correlation coefficients between variables, and the calculation formula is as follows:

$$KMO = \frac{\sum\sum_{i \neq j} r_{ij}^{\ 2}}{\sum\sum_{i \neq j} r_{ij}^{\ 2} + \sum\sum_{i \neq j} p_{ij}^{\ 2}}$$

$r_{ij}^{\ 2}$ is the simple correlation coefficient between variable i and variable j. $p_{ij}^{\ 2}$ is the partial correlation coefficient between variable i and variable j. The value of KMO is between 0 and 1. If the value of KMO is closer to 1, the sum of squares of simple correlation coefficients between all variables is much larger than the sum of squares of partial correlation coefficients, so it is more suitable for factor analysis, and vice versa.

Constructing Factor Variables

There are many methods to determine factor variables in factor analysis, among which principal component analysis of the principal component model is one of the most widely used factor analysis methods. Principal component analysis transforms the p original correlation variable x_i into another set of unrelated variables through coordinate transformation, which can be expressed as:

$$\begin{cases} F_1 = u_{11}x_1 + u_{21}x_2 \cdots + u_{p1}x_p \\ F_2 = u_{12}x_1 + u_{22}x_2 \cdots + u_{p2}x_p \\ \cdots \\ F_p = u_{1p}x_1 + u_{2p}x_2 \cdots + u_{pp}x_p \end{cases}$$

Notably, $u_{1k}^{\ 2} + u_{2k}^{\ 2} + \cdots + u_{pk}^{\ 2} = 1, (k = 1, 2, 3, \cdots, p)$

$F_1, F_2 \cdots, F_p$ is the first, second and the number p principal component of the original variable $\cdots$. Among them, F_1 occupies the largest proportion of the total variance and has the strongest ability to integrate original variables. The proportion of other principal components in the total variance gradually decreases, that is, the ability to integrate original variables decreases successively. The principal component analysis is to select the first several principal components with the largest variance, so as to achieve the goal of factor analysis with fewer variables, and at the same time to reflect the majority of the original variable information with fewer variables.

Factor analysis and principal component analysis have many similarities, both of them start from a covariance matrix in the process of calculation, but there are differences between the two models. The new variables obtained through factor analysis are analyzed inside each original variable. Factor analysis is not a recombination of the original variables, but a decomposition of the original variables into common factors and special factors. The factor analysis model is a model describing the covariance matrix Σ of the original index X. When $m = p$, ε should not be taken into consideration, and the factor analysis is also corresponding to a variable transformation. However, in practical application. m is always smaller than p, and the smaller the m is, the better. The mathematical model of principal component analysis is essentially a transformation, and in principal component analysis the corresponding coefficients a_{ij} of each principal component are uniquely determined, while in factor analysis the corresponding coefficients of each factor are not unique, that is, the factor loading matrix is not unique. In terms of the mathematical model of factor analysis, it is similar to multivariate regression analysis, but the essential difference is that the factor analysis model, as an "independent variable", F is not observable (unknown).

The principal component analysis steps are as follows:

(1) Standardized processing of data

$x_{ij}^{*} = \frac{x_{ij} - \overline{x_j}}{S_j}$,which $i = 1, 2, \cdots, n, n$ is the number of samples, and $\overline{x_j} = \frac{1}{n}\sum_{i=1}^{n} x_{ij}$ $j = 1, 2, \cdots, p, p$ is the number of sample variables. For convenience, this paper will still express via $\left[x_{ij}^{*}\right]_{n\times p} = \left[x_{ij}\right]_{n\times p}$.

(2) Calculate the covariance matrix R of the data $\left[x_{ij}\right]_{n\times p}$.

(3) Find the top m eigenvalue of R: $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_m$, and the corresponding eigenvector $u_1, u_2, \cdots, u_m$.

(4) Find the m factor loading matrix of a variable.

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{p1} & \cdots & a_{pm} \end{pmatrix} = \begin{pmatrix} u_{11}\sqrt{\lambda_1} & \cdots & u_{1m}\sqrt{\lambda_m} \\ \vdots & \ddots & \vdots \\ u_{p1}\sqrt{\lambda_1} & \cdots & u_{pm}\sqrt{\lambda_m} \end{pmatrix}$$

There are two ways to define m:

(1) One way is according to the eigenvalue, the eigenvalue obtained is generally greater than 1.

(2) Another method is taking the cumulative variance of the factors as a reference.

The cumulative variance contribution rate of the top m factors is calculated as follows:

$$Q = \frac{\sum_{i=1}^{m} \lambda_i}{\sum_{i=1}^{p} \lambda_i}$$

If the data has been standardized, then

$$Q = \frac{\sum_{i=1}^{m} \lambda_i}{p}$$

The cumulative contribution rate of general variance should be above 85%.

Naming Explanation of Factor Variables

The naming explanation of factor variables is a core problem in factor analysis. The result $F_1, F_2 \cdots, F_m$ of the principal component analysis is the synthesis of the original variables, which are all variables with physical meanings. The explanation of factor variables can further explain the main factors and system characteristics that affect the composition of the original variable system. In general, the factor variables and the original variables can be named by analyzing the value of the load matrix. There may be more than one large a_{ij} in a certain line in the load matrix A, indicating that a certain original variable x_i may have a relatively large

correlation with several factors at the same time. There may also be more than one large a_{ij} in a certain column, indicating that a factor variable may explain information about multiple original variables, but it explains only a small part of the information about a variable, and is not typical of any variable, which might make the meaning of a factor variable unclear, and then the process can be carried out through the rotation of the factor matrix, generally using the variance maximum method.

2.3.4 Calculating Factor Score

Calculating factor scores is the final step in factor analysis. After factor variables are determined, specific data values on different factors can be obtained for each data. These values are factor scores, which are corresponding to the score of the original variable.

To calculate factor scores, factor variables are first expressed as a linear combination of original variables, namely:

$$F_j = \beta_{j1}x_1 + \beta_{j2}x_2 + \cdots + \beta_{jp}x_p \ (j = 1, 2, \cdots, m),$$

Then give different weights to these variables, using the following comprehensive decision formula:

With comprehensive judgment, a comprehensive score can be attained. $F = a_1F_1 + a_2F_2 + \cdots + a_mF_m$

1.4 TOPSIS Algorithm

TOPSIS stands for “Sorting Methods Approaching Ideal Values”.

According to a number of indicators, the comparison of several schemes to choose the analysis method, this method is to first determine the central idea of the indicators are ideal value and the negative ideal value, is the so-called ideal value is one of the best value for a vision (plan). All attribute values achieve the best value of each candidate, and the negative ideal solution is another thought the worst value. Then the positive ideal value and the negative ideal value are calculated, and the approximation degree between each scheme and the optimal scheme is obtained as the criterion for evaluating the scheme.

The TOPSIS algorithm has its distinctive advantages. TOPSIS can fully reflect the gap between various programs, objectively and truly reflect the actual situation, with the advantages of real, intuitive, reliable, and no special requirements for its sample data. TOPSIS can centrally reflect the overall situation, comprehensively analyze and evaluate, and has universal applicability.

The TOPSIS process is carried out as follows:

Step 1

Create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria given as x_{ij}, we therefore have a matrix $(x_{ij})_{m\times n}$.

Step 2

The matrix $(x_{ij})_{m\times n}$ is then normalised to form the matrix

$R = (r_{ij})_{m\times n}$, using the normalisation method

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}}, \quad i = 1, 2, \ldots, m, \quad j = 1, 2, \ldots, n$$

Step 3

Calculate the weighted normalised decision matrix

$$t_{ij} = r_{ij} \cdot w_j, \quad i = 1, 2, \ldots, m, \quad j = 1, 2, \ldots, n$$

where $w_j = W_j \Big/ \sum_{k=1}^{n} W_k, j = 1, 2, \ldots, n$ so that $\sum_{i=1}^{n} w_i = 1$, and W_j is the original weight given to the indicator $v_j, \quad j = 1, 2, \ldots, n.$

Step 4

Determine the worst alternative (A_w) and the best alternative (A_b):

$$A_w = \{\langle \max(t_{ij} \mid i = 1, 2, \ldots, m) \mid j \in J_- \rangle, \langle \min(t_{ij} \mid i = 1, 2, \ldots, m) \mid j \in J_+ \rangle\} \equiv \{t_{wj} \mid j = 1, 2, \ldots, n\},$$

$$A_b = \{\langle \min(t_{ij} \mid i = 1, 2, \ldots, m) \mid j \in J_- \rangle, \langle \max(t_{ij} \mid i = 1, 2, \ldots, m) \mid j \in J_+ \rangle\} \equiv \{t_{bj} \mid j = 1, 2, \ldots, n\},$$

where,

$J_+ = \{j = 1, 2, \ldots, n \mid j\}$ associated with the criteria having a positive impact, and

$J_- = \{j = 1, 2, \ldots, n \mid j\}$ associated with the criteria having a negative impact.

Step 5

Calculate the L^2-distance between the target alternative i and the worst condition A_w

$$d_{iw} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{wj})^2}, \quad i = 1, 2, \ldots, m,$$

and the distance between the alternative i and the best condition A_b

$$d_{ib} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{bj})^2}, \quad i = 1, 2, \ldots, m$$

where d_{iw} and d_{ib} are L^2-norm distances from the target alternative i to the worst and best conditions, respectively.

Step 6

Calculate the similarity to the worst condition:

$s_{iw} = d_{iw}/(d_{iw} + d_{ib}), \quad 0 \le s_{iw} \le 1, \quad i = 1, 2, \ldots, m.$

$s_{iw} = 1$ if and only if the alternative solution has the best condition; and

$s_{iw} = 0$ if and only if the alternative solution has the worst condition.

Step 7

Rank the alternatives according to s_{iw} $(i = 1, 2, \ldots, m)$.

Three Analysis Examples

Data Collection

According to the 11 index variables set above, we designed the following questionnaire, which was distributed online and investigated groups of multiple age groups. These 11 factors were scored from 0 to 100. A high score indicates that the factor has a significant impact on the development of education, and thus can better measure the development of education in this region. A total of 80 valid samples were collected and downloaded to Excel. However, some people filled in unreasonable information. For example, each factor was scored above 90

or below 10, so these data were removed. The research requires the sample size to be at least 5 times of the target number, so the research finally analyzes the remaining 64 valid questionnaires.

(1) The data were manually removed and imported into SPSS. The results of the data obtained are listed as follows (Table 3):

Table 3. The Result of Questionnaires in SPSS

GDP	Number of colleges and universities	Income gap between urban and rural residents	Number of cultural relics	Number of population movements	Number of college students	University funds	Industrial structure	Traditional educational concept	Number of full-time teachers in Colleges and Universities	Urban and rural education system
81.00	58.00	52.00	90.00	40.00	78.00	77.00	57.00	38.00	50.00	16.00
91.00	59.00	855.00	78.00	84.00	89.00	86.00	90.00	92.00	87.00	93.00
54.00	51.00	49.00	80.00	76.00	81.00	80.00	83.00	86.00	62.00	39.00
95.00	89.00	88.00	95.00	98.00	89.00	85.00	100.00	95.00	47.00	66.00
82.00	51.00	48.00	33.00	35.00	82.00	92.00	50.00	100.00	54.00	20.00
56.00	56.00	82.00	77.00	85.00	82.00	90.00	99.00	64.00	51.00	23.00
89.00	40.00	41.00	95.00	17.00	80.00	79.00	95.00	94.00	83.00	11.00
90.00	70.00	60.00	90.00	95.00	100.00	95.00	100.00	85.00	100.00	40.00
94.00	87.00	75.00	100.00	90.00	94.00	100.00	82.00	94.00	51.00	58.00
73.00	35.00	11.00	94.00	9.00	17.00	69.00	54.00	86.00	20.00	13.00
80.00	64.00	96.00	92.00	87.00	81.00	100.00	85.00	83.00	100.00	39.00
93.00	86.00	77.00	77.00	70.00	74.00	82.00	82.00	29.00	32.00	30.00
66.00	73.00	59.00	13.00	61.00	89.00	64.00	52.00	42.00	81.00	47.00
26.00	66.00	81.00	45.00	58.00	59.00	.00	81.00	100.00	100.00	35.00
95.00	80.00	41.00	78.00	40.00	35.00	21.00	21.00	26.00	59.00	39.00
100.00	52.00	12.00	11.00	23.00	.00	38.00	27.00	25.00	.00	21.00
82.00	80.00	43.00	98.00	36.00	63.00	42.00	62.00	37.00	58.00	40.00
22.00	19.00	13.00	20.00	29.00	42.00	26.00	41.00	61.00	42.00	46.00
35.00	39.00	35.00	97.00	43.00	63.00	43.00	62.00	29.00	34.00	40.00
20.00	81.00	82.00	12.00	23.00	17.00	28.00	98.00	99.00	100.00	26.00
61.00	59.00	48.00	41.00	36.00	21.00	35.00	25.00	26.00	39.00	17.00
79.00	36.00	40.00	17.00	29.00	33.00	17.00	45.00	24.00	14.00	37.00

(2) Correlation analysis and sphericity test:

		GDP	Number of colleges and universities	Income gap between urban and rural residents	Number of cultural relics	Number of population movements	Number of college students	University funds	Industrial structure	Traditional educational concept	Number of full-time teachers in Colleges and Universities	Urban and rural education system
Correlation	GDP	1.000	-.100	.054	.107	.149	-.185	.745	.639	.147	-.173	.210
	Number of colleges and universities	-.100	1.000	-.232	.170	-.255	.718	-.129	-.004	.163	.711	-.198
	Income gap between urban and rural residents	.054	-.232	1.000	-.020	.738	-.196	.066	.052	-.232	-.178	.691
	Number of cultural relics	.107	.170	-.020	1.000	-.101	.002	.067	.175	.812	.067	.015
	Number of population movements	.149	-.255	.738	-.101	1.000	-.240	.165	.097	-.335	-.205	.722
	Number of college students	-.185	.718	-.196	.002	-.240	1.000	-.099	-.027	.054	.770	-.128
	University funds	.745	-.129	.066	.067	.165	-.099	1.000	.738	.118	-.046	.258
	industrial structure	.639	-.004	.052	.175	.097	-.027	.738	1.000	.188	-.079	.088
	Traditional educational concept	.147	.163	-.232	.812	-.335	.054	.118	.188	1.000	.142	-.221
	Number of full-time teachers in Colleges and Universities	-.173	.711	-.178	.067	-.205	.770	-.046	-.079	.142	1.000	-.152
	Urban and rural education system	.210	-.198	.691	.015	.722	-.128	.258	.088	-.221	-.152	1.000

Fig.1. The Result of a Sphericity Test

As is shown in Fig.1. above, it can be found that:

a. The number of ordinary colleges and universities, the number of full-time teachers in colleges and universities, and the number of college students have a large correlation coefficient of 0.718, 0.711 and 0.770, respectively;

b. The income gap between urban and rural residents, the education system between urban and rural areas, and the number of the floating population are highly correlated, with coefficients of 0.738, 0.691 and 0.722, respectively;

c. The correlation coefficients of GDP, university funding, and industrial structure were 0.745, 0.639 and 0.738, respectively;
d. The correlation coefficient of the number of cultural sites is 0.812.
e. This is also consistent with the factor classification results in the following section. The larger the correlation coefficient of the two variables is, the stronger the correlation is, and they can be divided into one category.

Table 4. KMO and Bartlett Test

KMO sampling suitability quantity.		.763
Bartlett Sphericity Test	Approximate chi square	210.079
	freedom	55
	Significance	.000

As Table 4 shows, the KMO test value, in this case, is 0.763, greater than 0.7, indicating that the sample data obtained is suitable for factor analysis and the effect should be positive. The significance of Bartlett's sphericity test is less than 0.05, indicating that the correlation matrix is not the identity matrix and there is a strong correlation between the selected variables.

Factor Analysis

The common factor variance (Table 5) and total variance were obtained by factor analysis of the data.

Table 5. The Common Factor Variance

	initial	extract
GDP	1.000	.789
Number of colleges and Universities	1.000	.795
Income gap between urban and rural residents	1.000	.817
Number of cultural relics	1.000	.934
Number of population movements	1.000	.834
Number of College Students	1.000	.852
University funds	1.000	.865
industrial structure	1.000	.778
Traditional educational concept	1.000	.916
Number of full-time teachers in Colleges and Universities	1.000	.835
Urban and rural education system	1.000	.810

Note: Extraction method: principal component analysis

The extraction of the original index by using the four extracted factors has reached more than 75%, indicating that the analysis result is relatively positive. Total variance interpretation, gravel plot, component matrix and rotated component matrix are as follows (Table 6):

Table 6. Total variance interpretation, gravel plot, component matrix and rotated component matrix

Component	Total	Initial eigenvalue Variance percentage	Accumulation %	Total	Extract sum of squares of load Variance percentage	Accumulation %	Total	Sum of squares of rotating loads Variance percentage	Accumulation %
1	3.356	30.512	30.512	3.356	30.512	30.512	2.482	22.562	22.562
2	2.512	22.839	53.352	2.512	22.839	53.352	2.478	22.529	45.091
3	1.902	17.288	70.639	1.902	17.288	70.639	2.437	22.153	67.245
4	1.454	13.216	83.856	1.454	13.216	83.856	1.827	16.611	83.856
5	.405	3.683	87.538						
6	.363	3.296	90.834						
7	.288	2.621	93.455						
8	.255	2.315	95.770						
9	.206	1.873	97.642						
10	.133	1.213	98.855						
11	.126	1.145	100.000						

Note: Extraction method: principal component analysis

First of all, from the interpretation of total variance, we artificially extracted four factors. The contribution rate of the first factor is 22.562%, the contribution rate of the second factor is 22.529%, and the cumulative contribution rate is 45.091%. The contribution rate of the third factor is 22.153%, and the cumulative contribution rate reaches 67.245%. The contribution rate of the fourth factor is 16.611%, and the cumulative contribution rate reaches 83.856%. It can be seen that the extraction of the four factors reflects most of the information of the original variable and also plays a role of dimensionality reduction.

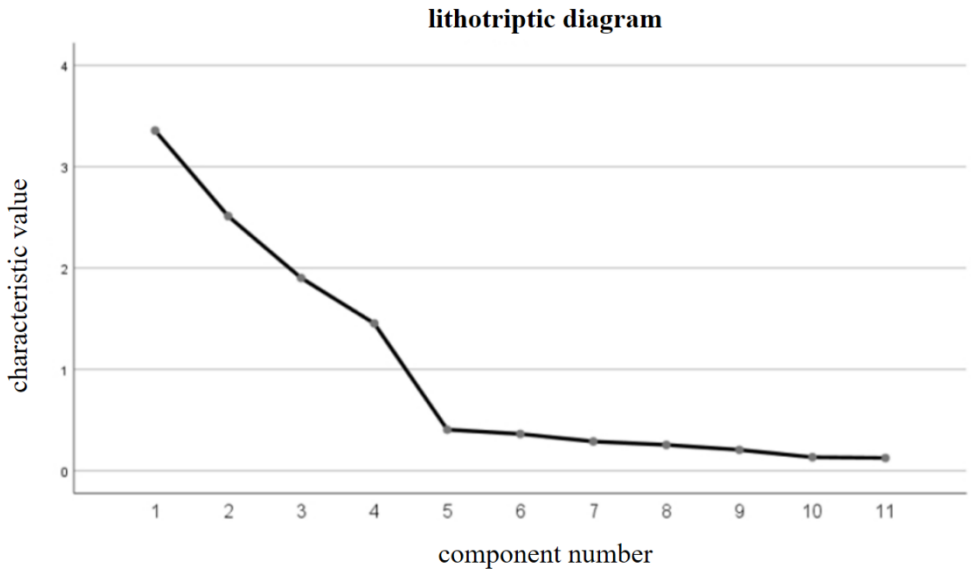

Fig. 2. The Principal Component Eigenvalues in the Lithotriptic Diagram

It can also be seen from the lithotriptic diagram that the principal component eigenvalues of the first four extracts are all greater than 1 (Fig. 2.), which is also consistent with the extraction results.

Table 7. Component Matrix for a Principle Component Analysis

Component Matrix [a]

	component			
	1	2	3	4
GDP	.453	.708	.006	-.286
Number of colleges and Universities	-.671	.217	.546	-.001
Income gap between urban and rural residents	.660	-.199	.465	.354
Number of cultural relics	-.149	.562	-.114	.764
Number of population movements	.734	-.178	.472	.202
Number of College Students	-.648	.117	.636	-.120
University funds	.447	.731	.113	-.344
industrial structure	.328	.768	.073	-.274
Traditional educational concept	-.308	.642	-.259	.585
Number of full-time teachers in Colleges and Universities	-.647	.156	.625	-.038
Urban and rural education system	.681	-.051	.521	.267

Note: Extraction method: a principal component analysis.

a. Four components were extracted.

Table 8. Principle Component Analysis with Caesar Normalization Maximum Variance Method

Component Matrix [a]

	component			
	1	2	3	4
GDP	-.128	.072	.873	.066
Number of colleges and Universities	.870	-.139	-.039	.128
Income gap between urban and rural residents	-.121	.895	-.021	-.023
Number of cultural relics	.049	.042	.059	.962
Number of population movements	-.146	.884	.090	-.149
Number of College Students	.915	-.099	-.053	-.042
University funds	-.034	.108	.923	.012
industrial structure	.011	.026	.874	.117
Traditional educational concept	.067	-.237	.128	.916
Number of full-time teachers in Colleges and Universities	.907	-.080	-.057	.047
Urban and rural education system	-.058	.885	.149	-.029

Note: Extraction method: a principal component analysis.

Rotation method: Caesar normalization maximum variance method.

a. The rotation has converged after 4 iterations.

As shown in Table 7 and Table 8, from the perspective of the component matrix alone, there is no significant difference in the coefficients of the 11 variables, with no coefficient exceeding 0.75, so there is no obvious differentiation and the effect is not positive. Therefore, the load rotation is carried out next, and the new total variance interpretation and rotated component matrix are obtained. From the perspective of the rotated

component matrix, the result of the rotated factor is better, the initial eleven indexes can be well matched with the four factors, and the degree of differentiation is improved. The rotated factor analysis model is as follows:

$$
\begin{aligned}
X_1 &= -0.128F_1 + 0.072F_2 + 0.873F_3 + 0.066F_4 + \varepsilon_1 \\
X_2 &= 0.870F_1 - 0.139F_2 - 0.039F_3 + 0.128F_4 + \varepsilon_2 \\
X_3 &= -0.121F_1 + 0.895F_2 - 0.021F_3 - 0.023F_4 + \varepsilon_3 \\
X_4 &= 0.049F_1 + 0.042F_2 + 0.059F_3 + 0.962F_4 + \varepsilon_4 \\
X_5 &= -0.146F_1 + 0.884F_2 + 0.090F_3 - 0.149F_4 + \varepsilon_5 \\
X_6 &= 0.915F_1 - 0.099F_2 - 0.053F_3 - 0.042F_4 + \varepsilon_6 \\
X_7 &= -0.034F_1 + 0.108F_2 + 0.923F_3 + 0.012F_4 + \varepsilon_7 \\
X_8 &= 0.011F_1 + 0.026F_2 + 0.874F_3 + 0.117F_4 + \varepsilon_8 \\
X_9 &= 0.067F_1 - 0.237F_2 + 0.128F_3 + 0.916F_4 + \varepsilon_9 \\
X_{10} &= 0.907F_1 - 0.080F_2 - 0.057F_3 + 0.047F_4 + \varepsilon_{10} \\
X_{11} &= -0.058F_1 + 0.885F_2 + 0.149F_3 - 0.029F_4 + \varepsilon_{11}
\end{aligned}
$$

Factor Naming

Education Popularization Factor

From the perspective of a rotated component matrix, the three variables involving the number of colleges and universities, college students in common colleges and universities, and the number of full-time teachers in colleges and universities are related to the three factors. From the number of colleges and universities, students, and teachers to measure the development level of local higher education, the three factors are the most intuitive for reflecting the local education popularity. The higher the popularity of higher education is, the higher the importance parents and students attach to education; the more reasonable the allocation of educational resources, the higher the level of teachers, the higher the quality of students, and the better the degree of educational development.

Therefore, the first factor can be named the "education popularization factor"**.** And because primary and secondary schools belong to compulsory education, all over the country's provinces have been launching compulsory education at the K-12 stage for many years, its popularity difference is not apparent, but the differences between the students in higher education are very obvious among different provinces. Education unbalanced development among provinces and the popularization of higher education gap are facing complicated challenges and of vital significance in China, so this study selects the data concerning enrollment of higher education, local teachers, and so on and so forth to reflect the education popularization index.

Urban-Rural Difference Factor

Moreover, the second factor is related to the three variables including the income gap of residents in urban and rural, population flow quantity, and urban and rural education systems. Because the urban and rural education

systems in different regions are different, some backward areas' education systems lead to the stability of the urban and rural population flow and urban and rural class solidification, which further brings about the imbalance of urban and rural education resources and education quality. And because of the influence of urban and rural residents' income gap, the residents in urban and rural areas enjoy different welfare in housing, education, employment, medical treatment.

To some degree, the rural population does not enjoy high-quality education, health care, and housing subsidies, while the urban population enjoys these benefits. Thus, the gap leads to a large number of population flows, like the rural population increasingly migrating to economically developed areas for giving their children quality education resources. As a result, the relatively backward areas fell into a vicious circle of "the more backward, the more deficient" education, and the education development level fell behind gradually. Therefore, the difference between urban and rural development is also an important factor affecting the level of local education development, so the second factor is named as "urban-rural difference factor".

Socio-Economic Factor

Furthermore, the third factor is related to GDP, the number of university funds, and the industrial structure. The influence of the economy on the development of education is broadly recognized, and the development of the social economy determines the scale and speed of education development, as well as the specification and quality of talent cultivation. GDP is the leading factor of regional economic development, and the form of industrial structure can affect the local financial revenue, and then affect the development of the local economy. The number of university funds is also affected by local economic development to a certain extent, so the third factor can be named the "socio-economic factor".

Traditional Cultural Factor

The fourth factor is closely relevant to two indicators involving the number of historical and cultural relics, and education traditional ideas, while the influence of these two indicators are less direct than the former three factors. These two indicators purify the learners' minds subtly through the local traditional culture or custom, which provides ideological education to the learners based on the cultural atmosphere of learning knowledge. For example, Qufu City in Shandong Province is the hometown of Confucius and Mencius, and the local cultural atmosphere is very intense. Children learn The Four Books and The Five Classics, which is about the Confucian culture in the feudal society in ancient China, as well as the thoughts of Confucius and Mencius from an early age, so that the local people generally respect teachers and respect the teachings of Confucius and Mencius, and education has developed rapidly. Therefore, the fourth factor can be named the "traditional cultural factor". In conclusion, these four common factors can explain the level of regional education development from four general directions, and also provide a certain reference for ameliorating the status quo of education development inequality in China.

Factor Score and Result Prediction

The 11 indicators are the main indicators affecting the development of regional education, which can reflect the development level of education to a certain extent. Also, the four factors extracted from the factor analysis are the common factors of these indicators, which intuitively reflects the level of education development. Arguably, if a new sample is available now, it is possible to use common factors as raw data for further analysis to make corresponding predictions about the level of education development in a place.

The component score coefficient matrix (Table 9) is shown as follows:

Table 9. The Component Score Coefficient Matrix

	composition			
	1	2	3	4
GDP	- 016.	- 033.	366.	- 033.
Number of ordinary universities	358.	032.	016.	026.
Income gap between urban and rural residents	030.	390.	- 074.	074.
Number of cultural sites	- 017.	105.	- 068.	562.
Number of migrations	029.	364.	- 013.	- 010.
Number of college students	388.	040.	026.	- 071.
The fund	033.	- 017.	394.	- 070.
The industrial structure	038.	- 037.	370.	- 014.
Traditional educational concept	- 031.	- 027.	- 013.	502.
Number of full-time teachers in colleges and universities	382.	056.	013.	- 016.
Urban and rural education system	064.	379.	005.	050.

Note: Extraction method: a principal component analysis

Rotation method: Kaiser normalized maximum variance method

The factor scoring formula is gained as follows:

$$F_1 = -0.016X_1 + 0.358X_2 + 0.030X_3 - 0.017X_4 + 0.029X_5 + 0.388X_6 + 0.033X_7 + 0.038X_8 - 0.031X_9 + 0.382X_{10} + 0.064X_{11}$$

$$F_2 = -0.033X_1 + 0.032X_2 + 0.390X_3 + 0.105X_4 + 0.364X_5 + 0.040X_6 - 0.0317X_7 - 0.037X_8 - 0.027X_9 + 0.056X_{10} + 0.379X_{11}$$

$$F_3 = 0.366X_1 + 0.016X_2 - 0.074X_3 - 0.068X_4 - 0.013X_5 + 0.026X_6 + 0.394X_7 + 0.370X_8 - 0.013X_9 + 0.013X_{10} + 0.005X_{11}$$

$$F_4 = -0.033X_1 + 0.026X_2 + 0.074X_3 - 0.562X_4 - 0.010X_5 - 0.071X_6 - 0.070X_7 - 0.014X_8 + 0.502X_9 - 0.016X_{10} + 0.050X_{11}$$

Using the data of 11 variables, the scores of the four common factors can be calculated respectively. The contribution rates of the four factors to the whole are also different, so the weighted average of them needs to be calculated as the comprehensive score of the regional education development level. At the same time, the four common factors F_1, F_2, F_3, F_4 play a major role in the contribution rate $\gamma_1 = 22.562, \gamma_2 = 22.529, \gamma_3 = 2.153, \gamma_4 = 16.611$ of the four comprehensive factors after rotation, so the weight can be set as the proportion of the contribution rate of each factor in the total contribution rate of the four common factors, and the sum of the weights is 1, so as to facilitate the comprehensive score of the educational development level of typical provinces.

Normalization can be obtained as follows:

$$\gamma_1 = \frac{\gamma_1}{\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4} = 27.0\%$$

$$\gamma_2 = \frac{\gamma_2}{\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4} = 26.8\%$$

$$\gamma_3 = \frac{\gamma_3}{\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4} = 26.4\%$$

$$\gamma_4 = \frac{\gamma_4}{\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4} = 19.8\%$$

It can be seen that the education popularization factor, urban-rural difference factor, social economic factor, and traditional culture factor account for 27.0%, 26.8%, 26.4%, and 19.8% respectively after normalization. According to the traditional idea, people often hold the view that economic level is the most dominant factor that affects the level of education, the more the economy developed areas would have the more advanced education. Moreover, according to the result of factor analysis, it can see that the economy is still the important factor influencing the level of education development, while education popularization, the differences between urban and rural development, and the influence of traditional culture also significantly interact with education. Therefore, in addition to the approaches like optimizing industrial structure, speeding up economic transformation, expanding the scale of the middle-income class, increasing GDP, and increasing educational funds, education can also be developed by other means, so some ideas and suggestions are proposed for improving the imbalance of educational development as follows:

(1) In view of the factor of the differences between urban and rural areas, policymakers can gradually narrow the development differences in medical care and housing between urban and rural areas by

improving urban and rural laws and regulations and education systems, or actively implementing urban-rural integration strategy, setting up rural schools, and developing rural compulsory education, so that rural and urban children can enjoy equal educational resources. Higher education funds should be subsidized to the children of disadvantaged families such as migrant workers, rural learners with a bad natural environment and poor families in backward areas, employees of enterprises with poor welfare, half-idle enterprises, undertakers of accidental risks (like debtors), primary physical laborers of township enterprises, and homeless people.

(2) In view of the education popularity factor, the government and relevant institutions ought to improve the education enrollment size, provide more college education funds allowance, enhance specialized-subject professional teachers' benefits, raise the teachers' social recognition, increase the number of scholarships to encourage all students to continue to accept higher education after compulsory education, and promote higher education personnel training to meet the needs of the transformation industry and labor market skills in order to increase returns to education and enhance social mobility.

(3) In view of the traditional cultural factor, although not as significant as the former three factors, the traditional cultural factor has a certain degree of fundamental influence on the education development level. Several related measures can be taken into consideration including building cultural and historical tourist attractions, posting publicity slogans about regional history and culture in the villages and towns, and utilizing media publicity for spreading local history and culture to encourage the rural population to accept higher education actively. At the same time, it is of great necessity to enhance the rural population's educational recognition and cultural confidence, and to improve the ethics and scientific literacy of the mass by developing regional education.

Comprehensive Score and Result Ranking

As the questionnaire scoring is highly subjective, the score of the factors is relatively subjective. In order to rationally reflect the direct differences in the levels of different provinces' education development, the research collects real data from each of the 31 provinces and autonomous regions in China, and uses the data as the four factors' index. After calculating the index with the TOPSIS algorithm, the normalization result of the index is within [0, 10], which is approximate to the alternative factor score, and factor contribution rate as the index weight. A linear combination is made to calculate the overall score, and finally the education development levels of 31 provinces are ranked accordingly. The calculation formula is as follows:

$$Z = \gamma_1 Z_1 + \gamma_2 Z_2 + \gamma_3 Z_3 + \gamma_4 Z_4$$

Z_1, Z_2, Z_3, Z_4 are the index values of education popularization factor, urban-rural difference factor, socio-economic factor, and traditional cultural factor of a certain province respectively, and Z is the comprehensive score of this province.

The index values Z_1, Z_2, Z_3, Z_4 are processed by using the TOPSIS algorithm. Because the sources of different index values are different, their values differ greatly and are affected by dimensional factors, so the TOPSIS algorithm is used to eliminate dimensionality and standardize the data to determine the positive ideal solution and negative ideal solution of the four factors. Then, the weighted Euclidean distance between the 31 index values under this factor and the positive ideal value, and the negative ideal value are calculated. After that, the queuing-comprehensive evaluation index of the index value is calculated, that is, the data between the normalization of [0,1]. At this time, the comprehensive score is too low and the difference is not obvious, so the index value is expanded by 10 times, and finally the index value is sorted into data between [0,10] to approximately replace the factor score of a certain province.

The calculation methods of the four main factor index values are as follows:

Z_1: Collected in 31 provinces in 2021 on the number of full-time teachers in colleges and universities and the number of regular institutions of higher learning data sets. Using the number of full-time teachers and the number of regular institutions of higher learning to attain a ratio, and the higher the average numerical meaning for each number of full-time teachers in colleges and universities, the greater the proportion of workers in the education industry in the region, the greater the chances of students in higher education attainment in the region, and the better the availability of higher education in the region.

Table 10 below shows the data processing of some provinces as an example:

Reigion	Initialized data	Normalized data
Anhui	1368.082645	7.601002344
Beijing	413.9021739	8.336789075
Fujian	1212.707865	5.467669011
Gansu	1657.938776	2.801002344
Guangdong	1880.80625	9.4256785
Guangxi	1788.270588	5.201002344
Guizhou	1719.866667	4.534335677
Hainan	1332.047619	3.583264586
Hebei	1787.073171	7.734335677

Z_2: The per capita disposable income of urban residents and rural residents in 31 provinces is collected, and the urban-rural difference in this aspect is obtained as the index value of the urban-rural difference factor. Contrary to the other three indicators, it is negatively correlated with the comprehensive score Z, that is, the greater the difference between urban and rural development, the greater the obstacle to educational development, and the lower the comprehensive score.

Table 11 as follows partly illustrates the data processing as an example.

Reigion	Initialized data	Normalized data
Anhui	24637	-5.471686487
Beijing	48215	-6.225689432
Fujian	27911	-4.489062789
Gansu	24754	-5.543779654
Guangdong	32548	-8.937475583
Guangxi	22167	-3.949719638
Guizhou	26355	-6.530285292
Hainan	22137	-3.93123421
Hebei	21612	-3.607739232

Z_3: Based on the ratio of the population of 31 provinces in 2021 to the provincial GDP, this paper obtains the per capita GDP. The value means that the higher the per capita GDP is, the better the local economy develops and the higher the educational resources are.

The data of some provinces are listed as follows (Table 12) as an example:

Reigion	Initialized data	Normalized data
Anhui	7325.563946	6.827646085
Beijing	8287.317934	9.445678954
Fujian	12515.47692	5.345678332
Gansu	4726.14853	3.495062218
Guangdong	16651.70407	8.754321168
Guangxi	5190.760608	4.090718728
Guizhou	5506.22249	2.456785489
Hainan	2501.183599	2.457788953
Hebei	5589.307258	4.601675972

Z_4 : This study collects the data set of the number of national, provincial, and county-level cultural relics protected units in 31 provinces, and assigns weights of 0.5, 0.3, and 0.2 respectively according to the national, provincial, and county-level cultural relics protected units, and makes a linear combination of the number corresponding to their levels to obtain the weighted average number of local cultural relics protected units. The numerical implication is that the more local cultural protection units there are, the more local people are influenced by traditional culture, the higher the quality of the population is, and the more attention they attach to education.

Part of the data is listed as follows (Table 13) as an example:

Reigion	Initialized data	Normalized data
Anhui	6113	5.864285714
Beijing	2188	4.859183673
Fujian	4188	3.9
Gansu	2490.02	2.167367347
Guangdong	12684	7.468885433
Guangxi	5037	4.766326531
Guizhou	3852	3.557142857
Hainan	1020.46	2.588854334
Hebei	7448	7.226530612

After a linear combination with weights of Z_1, Z_2, Z_3, Z_4, the comprehensive score and ranking of 31 provinces and autonomous regions are obtained as shown in the Table 14 below:

	Province	Education popularization factor	Urban-rural gap factor	Socioeconomic factor	Traditional cultural factor	Overall Score	Rank
2	Shandong	9.734335677	-5.479142276	8.822907071	9.355678843	5.341532381	1
3	Henan	9.934335677	-3.344568365	5.210064284	9.71122449	5.084205731	2
4	Beijing	8.336789075	-6.225689432	9.445678954	4.859183673	4.038225894	3
5	Sichuan	8.467669011	-4.998459548	5.886896366	8.169387755	4.11836289	4
6	Guangdong	9.4256785	-8.937475583	8.754321168	7.468885433	3.939669843	5
7	Hebei	7.734335677	-3.607739232	4.601675972	7.226530612	3.767092036	6
8	Hunan	8.201002344	-6.663380368	7.480138288	6.383673469	3.667208549	7
9	Shanghai	7.801002344	-6.422456789	9.188547899	4.166765306	3.635848389	8
10	Anhui	7.601002344	-5.471686487	6.827646085	5.864285714	3.549485792	9
11	Jilin	8.067669011	-2.448537345	4.902023479	3.67244898	3.543341721	10
12	Zhejiang	6.801002344	-6.357789996	8.123678854	6.3	3.524434131	11
13	Hubei	4.867669011	-3.858524863	6.732245679	5.575510204	3.161449849	12
14	Chongqing	6.134335677	-5.943064884	9.422359932	2.904520408	3.126127307	13
15	Jiangsu	3.934335677	-5.788532222	7.356764337	8.305102041	3.097539986	14
16	Liaoning	6.601002344	-4.976893216	7.068463875	3.942244898	3.095102204	15
17	Tianjin	3.267669011	-4.7901904	9.753634299	4.633567854	3.090905496	16
18	Heilongjiang	7.134335677	-3.563885756	5.335678954	2.815306122	2.937199107	17
19	Shanxi	5.001002344	-3.923840039	6.789232676	3.096408163	2.704127745	18
20	Jiangxi	6.333678999	-4.462998336	4.277889994	4.236122449	2.482124979	19
21	Fujian	5.467669011	-4.489062789	5.345678332	3.9	2.456660885	20
22	Guangxi	5.201002344	-3.949719638	4.090718728	4.766326531	2.369428167	21
23	Shaanxi	6.001002344	-6.291823279	5.743229996	3.66122449	2.175197162	22
24	Xinjiang	3.201002344	-3.888101547	6.806882874	2.186734694	2.052249967	23
25	Yunnan	5.001002344	-6.747797153	5.323840936	4.412244898	1.820979493	24
26	Inner Mongolia	3.134335677	-3.336188305	4.235897424	2.075510204	1.481400107	25
27	Hainan	3.583264586	-3.93123421	2.457788953	2.588854334	1.075360112	26
28	Guizhou	4.534335677	-6.530285292	2.456785489	3.557142857	0.827059829	27
29	Gansu	2.801002344	-5.543779654	3.495062218	2.167367347	0.622372846	28
30	Qinghai	1.3458826	-5.166060755	2.456778543	1.533567789	-0.068880023	29
31	Ningxia	1.456467888	-4.434654014	1.677836221	1.366788543	-0.081668052	30
32	Tibet	1.64482746	-5.345733366	1.97645679	1.45673678	-0.178334653	31

The following conclusions can be got in terms of the above data analysis:

(4) The comprehensive score of local education development level is related to the four public factors, and one of the four indicators is indispensable. The level of education development generally shows the trend of decline from the coast to the inland, from the east to the center to the west, and the level of economic development also shows this tendency, which is also one of the reasons that people believe

that "the more developed the economy, the more advanced the education". However, it can also be seen that the comprehensive score and economic development do not present a strict positive correlation, which is also explained in detail in the following section along with the corresponding conclusions.

(5) Taking Shanghai as an example, although its socio-economic factor and education popularization factor are high, its urban-rural difference factor score is low and its traditional cultural factor is medium, so its ranking is not in the top position. The result also accords with the current situation in Shanghai. As the economic center of China, Shanghai has a series of world-class and national top-tier universities like Fudan University with rich and prominent education resources. However, the urban development is too fast, while the rural development is relatively lagging, so the urban-rural income gap is too huge, causing the countryside students and surrounding city students especially focus on pursuing high-quality education resources, and some talents do not participate in the local fierce competition but go to other cities to receive higher education. Therefore, there might be a potential talent crisis in Shanghai, even though its education reform is implementing the overall development strategy of "sticking to the direction, deepening reform, increasing investment, improving quality, paying attention to efficiency, moderate development, social participation, and horizontal coordination".

(6) The final scores of Shandong Province and Henan Province are the highest in education popularization factor, traditional cultural factor, socio-economy factor, and urban-rural difference factor. This is also consistent with the current development conditions in these provinces. Shandong Province and Henan Province stay famous for their students' excellent academic performance in the national college entrance examination for a long time. Shandong Province is the hometown of Confucius and Mencius, and Henan Province is the birthplace of Chinese culture, with a large number of cultural relics and profound cultural deposits. Moreover, although the two provinces' economic development is not at the top in China, at least in the country is above the middle level, Shandong Province's GDP has ranked in the top three, and the education popularization of the two provinces is very high. Also, the two provinces have a high number of colleges and universities, quality teachers, and primary and secondary schools, which rank at the forefront of China, so both the education development level and teachers' competence are especially high. Besides, due to the large population base of the two provinces, the competition for college entrance examinations and postgraduate entrance examinations are accordingly extremely fierce. Parents and students in the two provinces thus attach great importance to education, which fundamentally improves the popularization and development level of education in the regions. The direction of education development in these two provinces should be on the premise of maintaining high-quality education to alleviate the excessive pressure of competition within the provinces.

(7) Tibet, Ningxia, Qinghai, and other remaining provinces are located inland, and the scores of the four factors are all low, so the comprehensive score is even negative. This is also consistent with their actual situations. Notably, China's education development imbalance is reflected in these provinces the most obvious. The low and backward development of education in western China closely is related to the factors such as backward economy and culture, low population quality and consciousness, and huge differences between urban and rural development. Therefore, China has been implementing national

policies such as “aid Tibet” and “voluntary teaching in disadvantaged areas”, and even launched rich preferential policies and incentive mechanisms for college students and civil servants in western China in terms of enrollment, employment, and promotion, which has played a great role in improving the status quo of unbalanced education development in China. The study hopes that these measures can be carried out all the time and strive continuously to send the “light and heat” of higher education to the students in the west. The development direction of these areas still ought to vigorously develop the economy of the region, strengthen the popularization of higher education, increase the investment of education funds, and gradually change the local backward education status quo.

Cluster Analysis

In the above sections, the education development levels of different regions in China have been comprehensively scored and ranked, the development status of typical regions has been analyzed, and development suggestions have been put forward.

However, for undergraduate students in universities, it is not the more developed areas, the more suitable for them to pursue further education in graduate schools, because education in the developed areas might show a trend of “involution”, or some developed areas’ education development level is high, but the number of “985 Project, and 211 Project” first-tier colleges and universities are inadequate, so which may be not suitable for the undergraduates at the Northeastern University for further study. Therefore, by investigating the undergraduate students’ postgraduate study target region, a valuable reference would be provided to the current juniors to choose a future university in a new region. Ten students were selected to score the 31 provinces from [0,5]. The higher the score that the students assess the province, the higher the degree of longing for the province. Part of the score result is listed as follows (Table 15):

Table 15. Part of the Questionnaires’ Results

	Region	A	B	C	D	E	F	G	H	I	J	AVE
2	Anhui	5	4	4	4	3	4	5	5	5	4	4.3
3	Beijing	5	5	5	5	4	4	5	5	5	5	4.8
4	Fujian	4	3	4	4	4	3	4	4	4	4	3.8
5	Gansu	3	4	1	4	1	4	3	4	4	4	3.2
6	Guangdong	4	5	5	5	4	5	4	5	5	4	4.6
7	Guangxi	2	5	2	5	2	5	1	1	5	3	3.1
8	Guizhou	5	3	3	1	5	1	5	4	1	1	2.9
9	Hainan	4	2	5	5	4	1	4	5	4	1	3.5
10	Hebei	2	5	5	5	4	4	1	2	4	3	3.5

The scoring results of ten students were clustered by systematic clustering method, measured as Euclidean distance method. The icicle diagram and pedigree diagram were obtained by cluster analysis with SPSS as follows (Fig.3.):

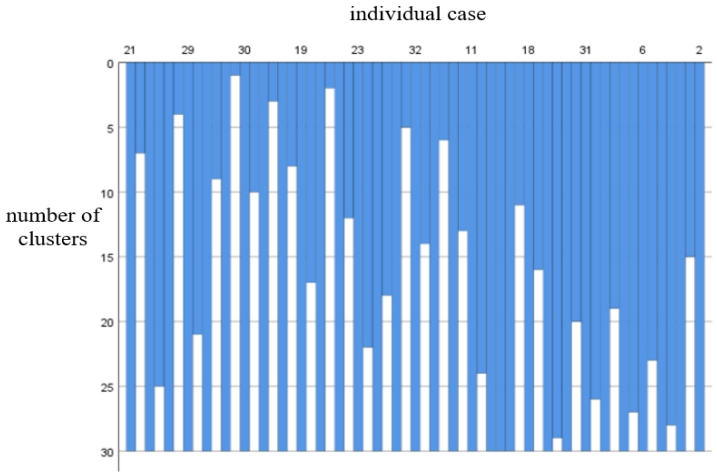

Fig.3. Number of Clusters and the Distribution of Individual Cases

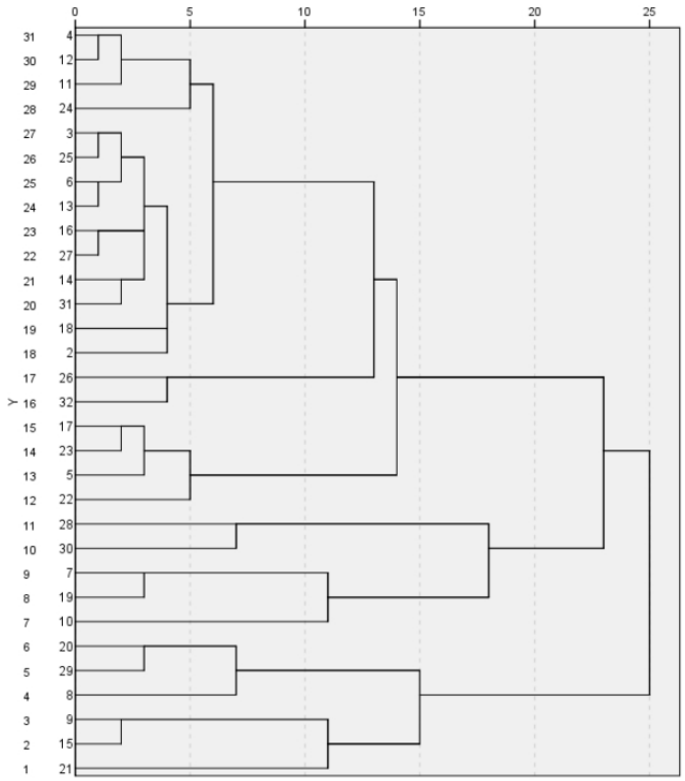

Fig.4. Pedigree using Average Join (between groups)

Rescaled distance clustering combination

According to the surveys of the ten students, the clustering results (Fig. 4.) show that the 31 provinces can be divided into six categories:

(1) Anhui, Beijing, Guangdong, Hunan, Jilin, Heilongjiang, Shanghai, Zhejiang, and Tianjin belong to the mutual group of provinces in the comprehensive score, and they are all rich in educational resources, which are also the first choice for students to study in graduate schools. The northeastern provinces like Heilongjiang and Jilin ranked slightly lower, but most of the respondents were students from Northeast

University, which is a university in northeastern China, so the surrounding northeast provinces were still popular among the participated students.

(2) Chongqing and Sichuan belong to the same type, which set in southwest China, with high-ranking universities as high-quality educational resources, which is suitable for students to register for graduate study.

(3) Hebei, Liaoning, Shandong, and Shanxi are in a common category. These provinces are all close to Northeast University and rank high in education level, making them a good choice for students from northeast China.

(4) Fujian, Henan, Hubei, Shaanxi, and Jiangxi are the same type. These provinces are moderately distant from northeast China and rank in the middle level of higher education.

(5) Qinghai, Jiangsu, Guizhou, Hainan, Ningxia, and Xinjiang belong to a group. Besides Jiangsu, these provinces have a lower ranking than other regions, and their geographical location is comparatively less advantaged, so they are more suitable for students to apply for as an adjustment choice.

(6) Gansu, Guangxi, Inner Mongolia, Tibet, and Yunnan belong to the same category. To some degree, they are all at the bottom of the higher educational level in China, located in the western inland region and far away from the northeast with a limited number of universities and a serious lack of educational resources.

The research finds a huge gap existing between relatively advanced eastern and less-developed middle and western provinces in China: the capital not only shows the highest density of universities, but also the high competence of top-tier higher education institutions. In contrast, several western and middle inland provinces suffer from an insufficiency, or undersupply, of quality HEIs relative to their population. Moreover, to some extent, both the quantity and quality indicators are low in provinces with large populations, provinces bordering other countries, and areas with large shares of ethnic minorities. Thus, the higher education indices analyzed in this research provide a meaningful reference for the improvement of the provision of reform policies in multiple provinces in China.

Conclusion

In this research, starting from the present situation of unbalanced education development in China, the impact factors which is likely to affect the level of China's education development were analyzed. Firstly, the study lists the 11 indexes that may affect the education development level, and further utilizes the factor analysis method to get the dimension of the indexes, extracts the four common factors, and obtains the four major factors influencing the level of education development in China. Then the factors are named and several suggestions are put forward to solve the problem of unbalanced education development in China. Furthermore, according to the factors of contribution rate and TOPSIS algorithm, the research calculates the comprehensive score and ranking of the education development level of 31 provinces in China. Moreover, this paper makes a detailed analysis of the provinces with large development differences, so as to systematically and comprehensively recognize the current situation of regional differences in China's education development level, and puts forward targeted

suggestions for the future education development direction of different categories of provinces. Finally, the research conducts a cluster analysis of the Northeastern University undergraduate students' preference for ideal provinces with graduate schools for further study. Thus, the results of the research also show practical and informative value to a certain group of students.

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Application of a Classified Prediction Model to Benefit the LTC Insurance

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Abstract: With the development of society and medicine, the birth rate and death rate are decreasing year by year, and the proportion of the elderly population is increasing dramatically, so the aging society has become a major issue. For the insurance industry, with the rapid increase of the elderly population, the huge demand for retirement, pension, medical care and long-term care (LTC) also arises. Insurance companies should grasp the needs of elderly clients, and then meet their needs (such as LTC insurance), provide clients with the safe life guarantee after retirement, and fulfill their corporate social responsibility. This study aims to establish the classified prediction model, first to dismantle the data with the percentage split, along with the application of feature selection and data discretization technique, finally by different categories of 3 classification algorithms, for the database data mining of insurance companies, to select 20 conditional attributes and 1 decision attribute to decide whether to buy the LTC insurance policy. The results of this study have two important contributions: (1) the "commercial LTC and disability insurance" is definitely a market with development potential; by using big data analysis tools and technologies, it can help the industry to screen out the potential client list and improve the income of life insurance companies; (2) the classified prediction model can be applied to other different industrial fields and produce different empirical analysis results to support different practical problems.

Keywords: Long-Term Care (LTC), Predication Model, Data Analysis

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Introduction

The sharp decrease in the number of elderly workers means that an aging society is coming, and the first thing is the emergence of care and support for the elderly. However, some young and strong working population, due to the illness or accident, also turns to the people being taken care of, and suddenly the family economy would face with the heavy loss, even food shortage, which would make the family caregiver in a panic. As the saying goes, "in nature there are unexpected storms and in life unpredictable vicissitudes." To avoid the aforementioned concerns, there is little public welfare other than the emergency reserve that one has saved, and then it has to rely on the savings or the family members, without dignity. The LTC usually provides the nursing and non-technical care, such as the assistance in dressing, bathroom use and other activities of daily living. In recent years, there are more and more LTC cases, which are the elderly population with multiple chronic diseases, who need to be handled by professionals with expertise. Therefore, the medical care services are gradually added to the LTC services. The LTC can be provided at home, in the community, supportive homes, nursing homes and respiratory care homes. LTC needs are likely to occur at all ages, but are most common among the elderly. By getting known of the LTC insurance, people can immediately activate the cost of follow-up care and nursing when an accident occurs, greatly reducing the burden. Therefore, this study combines the client information of life insurance companies and LTC insurance products as one of the options to solve the economic dilemma of LTC. Identifying the potential clients who might buy the LTC insurance is an important issue for life insurers.

Through the mature and widely applied data mining technology in various fields, such as smart city (Ageed, et al., 2021), fault detection (Baloch & Muhammad, 2021), Nutrition ranking (Aziz & Aftab, 2021), and titanium alloys (Zou, et al., 2021), especially the Naive Bayes classifier, Logistic, and IBk, etc., as well as other methods with good performance in other researches, it can solve the above problems. The purposes of this study can be finding the best classifier through the application of empirical study.

Literature Review

This section introduces the long-term care insurance, data mining, feature selection, data discretization, and classification algorithm.

LTC Insurance

Leroux et al. (2021) studied on the optimal LTC. The social insurance study is generally carried out under the utilitarian social standards, which penalize the individuals who have a low ability to convert the resources into welfare, such as dependent elderly people or those who die early. The design of optimal LTC insurance is re-examined, and the two egalitarian social standards of "ex ante and ex post" are adopted to give priority to the expected or realized worst case.

Data Analysis

Every day in the business, society, engineering science and daily life, there are a large number of data flowing in the Internet, and the main factor of such an explosive growth of data is the popularity of the Internet. Global business activities generate a huge stream of data, including the sales transactions, stock trading records, advertise push, operational data, and client feedback. However, the business activity is only one field of daily life, and there are many other uncounted data scattered across all walks of life. In the era of data explosion, this vast amount of data can be called the big data.

Data analysis of big data mining is also regarded as the gold mine of the new era. Everyone wants to mine the useful information from these data and convert the information into systematic knowledge. This demand drives the birth of data mining technology. In the medical (Noureddine, et al., 2022), governmental (Almeida, et al., 2021), educational (Nahar, et al., 2021), economic (Agusdinata, et al. 2021), cultural (Ai & Guo, 2022) and other aspects, there are huge amounts of data. However, when dealing with these huge amounts of data, it is often necessary to use the analytical technique to find the rules hidden in these data, and this process is called data analysis.

Feature Selection

Chandrashekar & Sahin (2014) found that the feature selection reduces the operation time, improves the predictive performance and better understands the machine learning or pattern recognition applications. It is to look for possible combinations of all conditions in the study data set and select the best set of prediction results.

Data Discretization

In data mining research, due to the limitation of huge data, resources and other reasons, the expert discretization cannot show the whole picture of the results, so the automatic discretization has become the favorite of researchers. The functions of data discretization include: (1) helping to reduce the number of rules generated, (2) improving the performance of classifier, and (3) cutting off the continuous attribute value. These excellent functions can improve the performance of the hybrid model. Data discretization research has been widely used, such as fuzzy model (Chen & Huang, 2021), rough sets theory (Pal & Kar, 2019), multi-scale and information entropy (Xun, et al., 2021), etc.

Classification Algorithm

Machine learning is an approach to solving problems in artificial intelligence. Algorithms are designed so that computers can learn and analyze them automatically. Many inferential problems are of programless difficulty, and part of machine learning research is to develop approachable algorithms. In order to reinforce learning to achieve goals, it makes adjustments as the environment changes, and does the post-action assessments for

positive and negative feedback. The machine learning is widely used in research field, such as robot (Li, et al., 2021), data mining (Asha Kiranmai & Jaya Laxmi, 2018), medicine (Hao, et al. 2021), search engine (Zhao, et al., 2021), financial market analysis (Gu, et al., 2022) and other fields. The data processing methods used in this study are mainly divided into 3 classifier algorithms: Naïve Bayes, Logistic, and IBk.

Research Framework

This study takes the data of a life insurance company in Taiwan as an empirical study. Firstly, it shall confirm the research project, plan the condition data required for the research, and obtain the condition data of life insurance clients from August 1997 to March 2021 from the database of A-Life Insurance Company. And the data is cleaned up and the data table is prepared. Then, the code is set up and the spreadsheet is prepared. Finally, the file format is converted into the format used in mining and prediction. The classification model algorithm in this study mainly consists of 10 steps, and the research framework is shown in Figure 1.

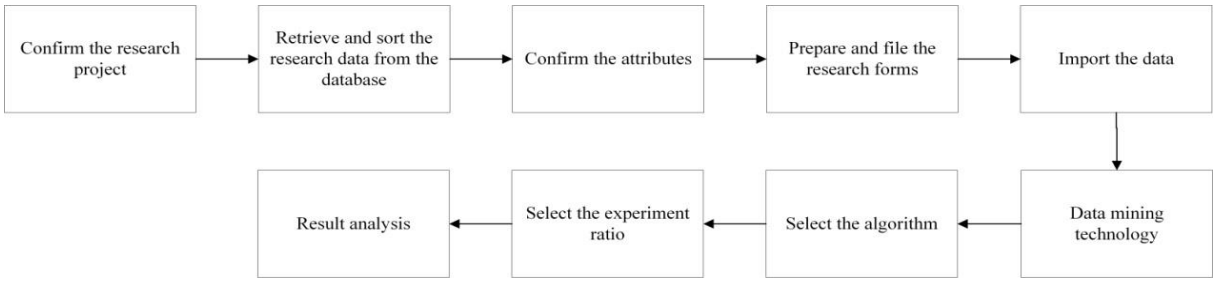

Figure 1. Research Framework of This Study

According to the research purpose, suitable algorithm is selected for machine learning training. In this study, 3 classifiers of mining tools commonly used in the academic world, including Naïve Bayes, Logistic, and IBk, are used for the percentage splits, namely the commonly used 67%/33% for the accuracy performance evaluation. The data set is divided into the training subset and testing subset, to find the best classifiers prediction.

In this study, through the supervision mode, two techniques, data dispersion and feature selection, are used to empirically analyze whether to purchase the LTC insurance policies according to the decision attribute. Subsequently, 473 pieces of research data are used for experimental sample testing.

Theoretical and Empirical Analysis

Further discussion and verification of the contributions and findings shall be carried out in two subsections respectively (experimental analysis and experimental results and findings).

Experimental Analysis

The classification algorithm is analyzed in this section. The classifiers prediction uses the A-Life insurance company's client data, with whether to buy the LTC insurance policies as the decision attribute and adopts 3 classifiers for the binary decision attribute by percentage split (67%/33%) for implementation, analysis, evaluation and calculation of performance to select the classifiers with better accuracy. After implementing functions of data discretization and attribute selection that by percentage split (67%/33%) is explained as follows: (1) Naïve Bayes: 73.7179, (2) Logistic: 83.3333, (3) IBk: 69.8718. The proportion performance value shows that from the evaluation value presented by the three classifiers (Naïve Bayes, Logistic, and IBk), with 83.3333% as the highest, 69.8718% as the lowest, and the difference value 13.4615%. Therefore, Logistic classifier is good performance in this study.

Experimental Results and Findings

The empirical result of percentage split has two-fold: (a) Logistic is the best classifier, and (b) IBk has the worst performance, for using the dataset of LTC insurance.

Conclusions

With rapid cloud computing and advanced and high-quality computerization, the technological development is the advantages of domestic enterprises. Insurance salesmen can get rid of the traditional sales methods in the early days: (1) stranger market development along the street, and (2) stranger telephone development, which is like looking for a needle in a haystack, consuming both energy and time, and achieving poor results. Sales performance is an important evaluation standard, the insurance company's client signing determines the salesman income. Through the client's basic policy content data of the insurance industry, this study applies the data mining technology, with the data pre-processing technology of attribute selection and data discretization, then uses the data evaluation (percentage split), to provide the insurance companies and salesmen in the development of potential clients on the list and achieve twice the result with half the effort with good performance.

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On The Construction of Symmetrical Methods and Step by Step Method for Their Application to Solving Initial-Value Problem for Odes

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Abstract: As is known one of the main issues in the theory of numerical methods is the determination of the reliability of the obtained values in the results of the application of numerical methods to solving some problems from different areas of natural sciences. For this purpose, some scientists suggested using symmetrical formulas. Noted that, at present time numerical methods are mainly used, which is associated with the wide reconciliation of computer technology. Therefore, here investigated the construction of the numerical methods by using symmetric methods or symmetrical formulas with the help of which it is possible to make some segments which will be the exact value of the problem under study. Given some recommendations for the construction of numerical methods. Using specific methods, it is shown that it is desirable to use the method with numerical step-size in the construction of the bilateral methods. For an illustration of what has been said, here have constructed the bilateral methods by using symmetrical formulas. Taking into account that the hybrid methods are symmetric, therefore, here for the construction of the bilateral methods is suggested using hybrid methods. For the comparisons of these methods consider the application some of them to solving the model problem. This work is a continuation of the previous ones, devoted to the construction of symmetrical formulas.

Keywords: Initial-value problem for ODEs, Symmetric and symmetrical methods, Multistep methods of hybrid type, Bilateral methods.

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Introduction

The investigation and application with ordinary differential equations begin with Newton's epoch. ODEs as an object of study in fundamental form, which investigated by many famous scientists from different countries. Among these works, a lot of places are occupied by the work devoted to the study of numerical methods. One can note the works of Euler, Adams, Runge, Kutta and etc. Recently scientists are increasingly publishing articles dedicated to the research of multistep multiderivative methods with constant coefficients. One of the promising directions in this area is the study of hybrid methods. Have proved the advantages of these methods one of which has related to the high order of accuracy of these methods. Here is defined of another advantage of these methods, which lies in the symmetry of these methods. Very often meet with the concept of symmetry in different fields of science. It is not a coincidence that they say everything in nature is arranged symmetrically. Now let us show the advantages of symmetric methods, which are used in the numerical solution of the following problem:

$$y' = f(x,y),\ y(x_0) = y_0,\ x_0 \le x \le X\ . \tag{1}$$

Suppose that continuous to totality of arguments function $f(x,y)$ defined in some closed area in which that has continuous partial derivatives up to some p, inclusively. And also assume that the unique solution of the problem (1) is defined on the segment $[x_0, X]$. For the determination of the numerical solution of the problem (1), let us divide the segment $[x_0, X]$ to N- equal parts by the mesh points $x_{i+1} = x_i + h, (i = 0,1,.., N-1; x_N = X)$. Here $0 < h$-is the step-size. And to denote the exact and approximate values of the solution at the point x_i, by the $y(x_i)$ and y_i, correspondingly.

It is known that for the determination of the numerical solution of problem (1) one can used multistep method with constant coefficients presented as the following (see for example [1]-[8]):

$$\sum_{i=0}^{k} \alpha_i y_{n+i} = h \sum_{i=0}^{k} \beta_i f_{n+i}\ . \tag{2}$$

In the work [2] proved that the stability of the method (2) is necessary and sufficient for its convergence. But in the work [1] proved that if the method (2) is stable, then $p \le 2[k/2] + 2$ and for all the value of k, there exist the stable methods with $p_{\max}$, here p-is the degree for the method (2). For the conceptions of the stability and degree, here have been used the following definitions (see for example [1]-[14]).

Definition 1. Method (2) is called as stable, if the roots of the polynomial $\rho(\lambda)=\alpha_k\lambda^k+\alpha_{k-1}\lambda^{k-1}+...+\alpha_1\lambda+\alpha_0$ lie in the unite circle on the boundary of which there is no multiply roots.

Definition 2. The integer value p called as degree for the method (2) if the following asymptotic equality is hold:

$$\sum_{i=0}^{k}(\alpha_i y(x+ih)-h\beta_i y'(x+ih))=O(h^{p+1}),\ h\to 0. \tag{3}$$

Taking into account some positive properties of symmetric methods, let us consider the construction some of symmetric methods.

Construction of Simple Symmetrical Multistep Methods

There are some ways for determination of the symmetry of multistep methods with constant coefficients. One of these is the Dahlquist's rule, which can be presented as follows:

Definition 3. Stable method (2) with the degree $p=k+2$ called as the symmetric if the following is holds:

$$\alpha_i=-\alpha_{k-i};\ \beta_i=\beta_{k-2}\ (i=0,1,..,k). \tag{4}$$

Hence it follows that the symmetric methods can be fiend for even value of k (k -is the order of the method (2)).

Let us consider the following known methods:

$$y_{n+1}=y_n+hf(x_{n+1/2},y_{n+1/2});\ y_{n+1}=y_n+h(f(x_n,y_n)+f(x_{n+1},y_{n+1}))/2,$$

which are called as the midpoint and trapezoidal rule, respectively. The coefficients of these methods satisfies the condition of (4), but the condition $p=k+2$ are not satisfies. However, the specialists are uses these methods as the symmetric. Therefore, the concept of the symmetry for the multistep methods needs to be adjusted. In one version this problem can be solved as the following form: stable method (2) called as the symmetric if the condition of (4) is hold and the degree of the considering methods receive the own maximum value. Noted that the degree for the midpoint and trapezoidal rule receive the own maximum value. As is known midpoint rule can been presented as follows:

$$y_{n+2}=y_n+2hf(x_{n+1},y_{n+1}), \tag{5}$$

which is stable and has the degree $p = 2$. By taking into account that, this method is explicit, then receive that the degree for the method (5) can be presented as $p_{\max} = 2$. It follows noted that the degree for the trapezoidal rule also receive the own maximum degree. Method (5) follows from the method (2) for the value $k = 2$, but the trapezoidal rule for the value $k = 1$. From the method (2) for the value $k = 1$ one can be receive the following Euler's methods:

$$\bar{y}_{n+1} = \bar{y}_n + hf(x_n, \bar{y}_n),\ y_{n+1} = y_n + hf(x_{n+1}, y_{n+1}).$$

The first method is explicit, but the second one is the implicit. The exact value of the solution of problem (1) by using Euler's methods can be presented as the following:

$$\bar{y}(x_{n+1}) = y(x_n) + hf(x_n, y(x_n)) + \frac{h^2}{2!} y''(x_n) + O(h^3), \quad (6)$$

$$y(x_{n+1}) = y(x_n) + hf(x_{n+1}, y(x_{n+1})) - \frac{h^2}{2!} y''(x_n) + O(h^3), \quad (7)$$

here $\bar{y}(x_{n+1}) = y(x_{n+1})$ exact value of the solution of problem (1) at the mesh-point x_{n+1}. Noted that, from the initial-value problem (1), receive that $y_n = y(x_n)$.From the equalities (6) and (7) receive that the exact value of the solution $y(x)$ located between the values $\bar{y}_{n+1}$ and y_{n+1}. From here receive that if $y''(x) > 0$ $(x_0 \le x \le X)$, then the following take place (see [15]):

$$\bar{y}_{n+1} \le y(x_{n+1}) \le y_{n+1}. \quad (8)$$

By using the equality of (8) one can be determined that the resulting approximate value is how close to the exact value of the solution of problem (1). By using equalities (6) and (7) in the equality of (8) one can constructed the following bilateral method:

$$\hat{y}_{n+1} = y_n + f(x_n, y_n),\ \bar{y}_{n+1} = y_n + hf(x_{n+1}.\hat{y}_{n+1}),\ y_{n+1} = (\hat{y}_{n+1} + \bar{y}_{n+1})/2.$$

Noted that if used the half sum calculation of values according to Euler's methods, then receive that this value will be more exact, than the values calculating by the Euler's methods. As a result of such an operation, obtain the trapezoidal rule, which has the degree $p = 2$, but Euler's methods have the degree $p = 1$. Noted that Euler's method is not symmetric, but method constructed by using Euler's methods is symmetric. Let us noted that Euler's methods can be taken as the symmetric methods, so as the values calculated by the Euler's methods

are satisfies the condition of (8) and the coefficients of the main terms in the asymptotic equalities of local errors are coincide in absolute value.

As is known, by using the approximately values calculated by the methods of predictor and corrector one can determine the bounders to change of the step-size h. For the demonstration of this, let us to consider the following predictor and corrector methods:

$$\bar{y}_{n+2} = y_n + 2hf(x_{n+1}, y_{n+1}), \tag{9}$$

$$y_{n+2} = y_n + 2h(f(x_{n+2}, y_{n+2}) + f(x_{n+1}, y_{n+1}) + f(x_n, y_n))/3. \tag{10}$$

The methods (9) and (10) has the same order of accuracy and the approximate value $\hat{y}_{n+2}$ -is corrected by the method of (10) (it is known that the approximate values calculated by the stable implicit methods usually are more accurate).

Noted that the exact values calculated by the methods (9) and (10) can be presented as follows:

$$\hat{y}(x_{n+2}) = y(x_n) + 2hf(x_{n+1}, y(x_{n+1}) + h^3 y'''(x_n)/3 + h^3 y^{IV}(x_n)/3 + O(h^5), \tag{11}$$

$$y(x_{n+2}) = y(x_n) + 2h(f(x_{n+2}, y_{n+2}) + f(x_{n+1}, y_{n+1}) + f(x_n, y_n))/3 - h^3 y'''(x_n)/3 - h^4 y^{IV}(x_n)/3 + O(h^5), \tag{12}$$

here have used the presentation local transition error from the work [16].
If find the half sum of this values, then have:

$$y(x_{n+2}) = y(x_n) + h(f(x_{n+2}, y(x_{n+2}) + 4f(x_{n+1}, y(x_{n+1})) + f(x_n, y(x_n)))/3 + O(h^5).$$

The method obtained by the above scheme is the Simpson's method, which is stable has the degree $p = 4$ and is symmetric. Noted that the methods (11) and (12) are also symmetric. It is known that the hybrid methods have the high order of accuracy (see for example [17]-[24]). By using the equalities of (11) and (12) receive that the methods (9) and (10) can be taken as the symmetric methods (see equalities (11) and (12)). In this case predictor-corrector method constructed as the following form:

$$\hat{y}_{n+2} = y_n + 2hf(x_{n+1}, y_{n+1}),\ \bar{y}_{n+2} = y_n + 2h(f(x_{n+2}, \hat{y}_{n+2}) + f(x_{n+1}, y_{n+1}) + f(x_n, y))/3,$$

$$y_{n+2} = (\hat{y}_{n+2} + \bar{y}_{n+2})/2, \tag{13}$$

which can be taken as the bilateral method.
And now let us consider to construction bilateral methods by using methods of hybrid type.

Construction the Symmetrical Methods by Using Hybrid Methods

One of the promising methods in solving initial-value problem for ODEs is the hybrid methods, which can be compares with the Gauss quadrature method. Note that there are direct connections between the Gauss and hybrid methods. As is known Gauss nodes are located symmetrically and the corresponding coefficients are positive and also located symmetrically (see for example [25,p.190-199]). Consequently by taking into account the symmetry properties of the Gaussian method, obtain that the hybrid methods are also symmetric. Let us consider the following simple multistep method of hybrid type:

$$\sum_{i=0}^{k}\alpha_i y_{n+i} = h\sum_{i=0}^{k}\gamma_i f(x_{n+i+\nu_i}, y_{n+i+\nu_i}) \ (|\nu_i|<1;\ i=0,1,2,...,k), \tag{14}$$

here the coefficients $\alpha_i, \beta_i, \nu_i (i=0,1,..,k)$ are real numbers and $\alpha_k \neq 0$. Well known representative of this method, can be presented as follows:

$$y_{n+1}= y_n + h(f(x_{n+1/2-\alpha}, y_{n+1/2-\alpha}) + f(x_{n+1/2+\alpha}, y_{n+1/2+\alpha}))/2,\ \alpha=\sqrt{3}/6. \tag{15}$$

Hybrid method of (15) is stable and has degree of $p=4$ and is symmetric. This method can be take better than the Gauss method receiving in [25,p.190-199]. Note that the use of this method is more difficult so let's simplify it. In this one can be offer the following method:

$$y_{n+1} = y_n + hf(x_n + h/2, y_{n+1/2}).$$

The difficulty in applying of this method lies in the calculation of the values $y_{n+1/2-\alpha}$ and $y_{n+1/2+\alpha}$. Note that one of these values can be expressed in terms of the others. To get rid of irrational number α, here decided to simplify the given method of (15). In the results of which constructed the following methods:

$$y_{n+1}= y_n + h(f_{n+1} + 3f_{n+1/3})/4;\ y_{n+1}= y_n + h(f_n + 3f_{n+2/3})/4. \tag{16}$$

These methods have the degree $p=3$. By using Taylor series one from the methods (16) can be receive the following:

$$y(x_{n+1}) = y(x_n) + h(f(x_{n+1}, y(x_{n+1})) + 3f(x_n + h/3, y(x_n + h/3)))/4 - ch^4 y^{(4)}_{(x_n)} + O(h^5),$$

$$y(x_{n+1}) = y(x_n) + h(f(x_n, y(x_n)) + 3f(x_n + 2h/3, y(x_n + 2h/3)))/4 + ch^4 y^{(4)}_{(x_n)} + O(h^5). \tag{17}$$

Consequently, methods (16) can be taking as the symmetric, in other words the exact value of the solution of the problem (1) will be located between of the values calculated by the methods (16). The more information about symmetric methods can be found in some works (see for example [26]-[36]). The main difficulty in using the methods (17) lies in the calculation of the values $y_{n+1/3}$ and $y_{n+2/3}$. By using that the degrees of these methods equals to 3, then receive that values $y_{n+1/3}$ and $y_{n+2/3}$ must be calculate with the rate of approaches $p \geq 2$. Consequently to calculation of the values $y_{n+1/3}$ and $y_{n+2/3}$ one can be use the trapezoid method. In this case receive, that

$$\hat{y}_{n+2/3} = y_n + 2hf(x_n, y_n)/3, \tag{18}$$

$$\bar{y}_{n+2/3} = y_n + 2h(f(x_n, y_n) + f(x_{n+2/3}, \hat{y}_{n+2/3}))/3, \tag{19}$$

which is the predictor-corrector method and constructed by the methods Euler and Trapezoid.

This method is implicit, therefor application of that to solve some problem are use the above mentioned predictor-corrector method. By using methods (18) and (19) one can be applied the following method to solve some problems:

$$y_{n+1} = y_n + h(f(x_n, y_n) + 3f(x_{n+2/3}, \bar{y}_{n+2/3}))/4. \tag{20}$$

And now let us to consider the construction predictor-corrector method for using other method in the sequences methods of (16) (see [7]). In one version one can be suggested the following predictor-corrector method, considering some similarities with the method of (20):

$$\hat{y}_{n+1} = y_n + hf(x_n, y_n);\ \hat{y}_{n+1/3} = y_n + hf(x_n, y_n)/3; \tag{21}$$

$$\bar{y}_{n+1} = y_n + h(f(x_n, y_n) + f(x_{n+1}, \hat{y}_{n+1}))/2\ \bar{y}_{n+1/3} = y_n + h(f(x_n, y_n) + f(x_{n+1/3}, \hat{y}_{n+1/3}))/6; \tag{22}$$

$$y_{n+1} = y_n + h(f(x_{n+1}, \bar{y}_{n+1}) + 3f(x_{n+1/3}, \bar{y}_{n+1/3}))/4. \tag{23}$$

If compare the methods (20) and (23), then receive that the methods (20) and (23) can be taking as similarly. But method (20) is explicit, therefor in the application of which to solve problem (1) are not arises any difficulties. Noted that in the application of the method (23) to solve problem (1) it is arises some difficult so as method (22) is implicit. It follows from here that, application of the method (22) is complexity. But the application of the method (22) is needed to some simplicity. It is easy to show that in the application of method (22) to solve some problem (1) are not arise any difficulties. Thus, here have constructed step by step algorithm for the application of the methods (16) to solve problem (1).

And now let us to consider comparison of the methods (15) and (16). Method of (15) has the degree $p = 4$, but the degree for the methods of (16) is equals to $p = 3$ and by using methods (16) one can constructed method with the degree $p = 4$.

According to the scheme described above, have identified the disadvantages of the method (16). Now, let us to define disadvantages for the method of (15). It is obvious that by using known methods as Adams or multistep to calculate values $y_{n+\alpha}$ or $y_{n+1-\alpha}$ is impossible. Therefore, to calculate this value, one needs to construct special methods. It should be noted that when using method (16), we obtain on estimate for the exact values of the solution of the proposed problem. Therefore, it is preferable to use method (16) in solving applied problems. Let us show that by using methods (16) one can be constructed bilateral method. To this end for the simplicity suppose that $y_{(x)}^{(IV)} > 0$. In this case by the comparison the methods of (17), receive:

$$\underline{y}_{n+1} \le y(x_{n+1}) \le \bar{y}_{n+1}, \tag{24}$$

here the values $\underline{y}_{n+1}$ and $\bar{y}_{n+1}$ calculate by the following methods:

$$\underline{y}_{n+1} = y_n + h(f_n + 3f_{n+2/3})/4,$$
$$\bar{y}_{n+1} = y_n + h(f_{n+1} + 3f_{n+1/3})/4,$$

and $y_{n+1} = (\underline{y}_{n+1} + \bar{y}_{n+1})/2,$ here $y_{(x)}^{(4)} > 0$. But if $y_{(x)}^{(4)} < 0$, then

$$\underline{y}_{n+1} = y_n + h(f_{n+1} + 3f_{n+1/3})/4,\ \bar{y}_{n+1} = y_n + h(f_n + 3f_{n+2/3})/4.$$

By above described, have shown that, how one can be construct bilateral method by using symmetrical methods, if the coefficients satisfies the condition: $\beta_j \ge 0 \ \ (0 \le j \le k)$.

If the formulas are used in the construction of bilateral methods and there is a term with negative coefficient, then in this term it is necessary to use other meaning instead of this $\bar{y}_m$ and to contrary.

Numerical Results

It is known that there are some works dedicated to investigation of the construction and application symmetric methods. However, the construction of two-sided formulas, as well as the construction of bilateral methods are

almost don't investigation up to now. For comparison the results receiving by the methods (9) and (10) let us consider to solving following initial-value problems:

$$y' = \lambda y \;,\; y(0) = 1,\; 0 \le x \le 1, \tag{25}$$

the exact solution for which can be presented as the $y(x) = \exp(\lambda x)$.

To solving the given problem have been used the methods (9),(10) and (13) taking into account that methods (9) and (10) satisfies the inequality (24).

As was noted above formula (13) is one and the same with Simpson's method. Therefor example (25) has been solved by the methods (9), (10), (13) and Simpson's methods. For the shown the advantages of hybrid methods, here to solve example of (25) has applied hybrid method of (15). The receiving results have tabulated in the Table 1and 2.

Table 1. Results Receiving by the Methods (15),(9),(10),(13) and Simpson's for $h = 0.1$.

$m=1$						$m=-1$					
x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$	x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$
0.1	4.2E-6	3.6E-4	3.4E-4	1.2E-5	1.2E-5	0.1	4.E-6	3.E-4	3.2E-4	1.E-5	1.E-5
0.4	2.2E-5	5.1E-4	4.4E-4	3.6E-5	3.6E-5	0.4	1.2E-5	2.1E-4	2.4E-4	1.2E-5	1.2E-5
0.7	5.4E-5	7.4E-4	5.5E-4	9E-5	9E-5	0.7	1.5E-5	1.4E-4	1.9E-4	2.3E-5	2.3E-5
1	1.E-4	1.E-3	7.1E-4	1.6E-4	1.6E-4	1	1.6E-5	1.1E-4	1.4E-4	1.6E-5	1.6E-5
$m=5$						$m=-5$					
x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$	x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$
0.1	2.8E-3	6.9E-2	4.7E-2	1.1E-2	1.1E-2	0.1	2.3E-3	2.5E-2	3.4E-2	4.4E-3	4.4E-3
0.4	5.1E-2	0.4E0	1.2E-1	1.4E-1	1.4E-1	0.4	2E-3	9.6E-3	7.8E-3	8.7E-4	8.7E-4
0.7	4E-1	2E0	9.5E-2	1E0	1E0	0.7	8.1E-4	4.9E-3	3E-3	3.9E-3	3.9E-3
1	2.5E0	1.1E+1	1.5E0	6.7E0	6.7E0	1	2.5E-4	8E-3	7.2 E-4	4.3E-3	4.3E-3

Here by the $\varepsilon, \varepsilon 1, \varepsilon 2, \varepsilon 3$ and $\varepsilon 4$ are designed of the errors obtained by the methods (15),(9),(10), (13) and Simpson's.

Table 2. Results receiving by the methods (15),(9),(10),(13) and Simpson's for $h = 0.05$.

$m=1$						$m=5$					
x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$	x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$
0.1	5.5E-7	4.6E-5	4.4E-5	8.1E-7	8.1E-7	0.1	4.3E-4	8.8E-3	7.E-3	9E-4	9E-4

0.4	2.9E-6	6.5E-5	5.6E-5	4.3E-6	4.3E-6	0.4	7.8E-3	5.1E-2	2.E-2	1.5E-2	1.5E-2
0.7	7.0E-6	9.2E-5	7.2E-5	1E-5	1E-5	0.7	6.1E-2	2.7E-1	4.E-2	1.1E-1	1.1E-1
1	1.3E-5	1.3E-4	9.1E-5	1.9E-5	1.9E-5	1	3.9E-1	1.4E0	3.8E-2	7.5E-1	7.5E-1
$m=-1$						$m=-5$					
x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$	x	ε	$\varepsilon 1$	$\varepsilon 2$	$\varepsilon 3$	$\varepsilon 4$
0.1	4.9E-7	3.7E-5	3.8E-5	5.8E-7	5.8E-7	0.1	2.4E-4	3.3E-3	3.6E-3	1.6E-4	1.6E-4
0.4	1.4E-6	2.6E-5	3E-5	1.7E-6	1.7E-6	0.4	2.1E-4	8E-4	8.6E-4	3E-5	3E-5
0.7	1.8E-6	1.8E-5	2.3E-5	2.2E-6	2.2E-6	0.7	8.4E-5	4.6E-4	6.9E-5	1.9E-4	1.9E-4
1	1.9E-6	1.3E-5	1.7E-5	2.3E-6	2.3E-6	1	2.6E-5	5.7E-4	2.1 E-4	3.9E-4	3.9E-4

Noted that the method (13) and Simpson's method are one and the same. But method (13) is consists of several formulas. Given that the local error for these methods is summed up, then one can say that the error of method (13) should be greater than the Simpson method. This did not happen in our example because the result obtained by the method (13) was used as the initial values. If the methods (9) and (10) are used as am indented object, in this case the error for that methods are increases. Thus receive that it is desirable the algorithm constructs in the following form:

Algorithm for the application of the method (15) to solve problem (1).

Input end points x_0, X , integer N , initial condition $\alpha = y0$.

Out put i, x_i, y_i, h where at the h step y_i approximates $y(x_i)$ and the step size h was used.

Step1. Set $h=(X-x_0)/N;\ t=x_0;\ y[0]:=1;\ y[1]:=\exp(m*h);$

$w=y[0];\ y3[0]:=y[0];\ y3[1]:=y[1];\ l=(3-sqrt(3))/6;$

Output (t,w) .

Step 2. For $i=0,1,..,N-1$ do begin

$$\bar{y}_{i+l}=y_i+lh(f(x_i,y_i)+f(x_{i+l},y_i))/2;$$

$$\bar{y}_{i+l}=y_i+lh(f(x_i,y_i)+f(x_{i+l},\bar{y}_{i+l}))/2;$$

$$\hat{y}_{i+1-l}=y_i+(1-l)h(f(x_i,y_i)+f(x_{i+1-l},y_i))/2;$$

$$\hat{y}_{i+1-l}=y_i+(1-l)h(f(x_i,y_i)+f(x_{i+1-l},\hat{y}_{i+1-l}))/2;$$

$$y_{i+1}=y_i+h(f(x_{i+l},\bar{y}_{i+l})+f(x_{i+1-l},\hat{y}_{i+1-l}))/2;$$

$$y1[i+2]=y3[i]+2hf(x_{i+1},y3[i+1]);$$

$$y2[i+2]=y3_i+2h(f(x_{i+2},y1[i+2])+f(x_{i+1},y3[i+1])+f(x_i,y3[i]))/3;$$

$$y3[i+2]=(y1[i+2],y2[i+2])/2;$$

$$y4[i+2]=y3[i]+2h(f(x_{i+2},y1[i+2])+4f(x_{i+1},y3[i+2])+f(x_i,y3[i]))/3;$$

$$eps = \exp(\lambda x_{i+1}) - y_{i+1};\ \ eps1 = \exp(\lambda x_{i+2}) - y1[i+2];$$

Remark

In the work [32]-[38] are constructed the symmetric methods, which have applied to solve of Volterra integral equations with symmetric boundaries. And in the work [34] have constructed the symmetric methods which have applied to solve Volterra integral equations and have given some comparison with the results receiving by the advanced methods. By taking into account that the construction simple methods to calculation of definite integrals is one of the popular problems in modern natural sciences, have considered to construction methods with improved properties that were applied to solve popular problems like as the Schrodinger and Duffing equations, orbital and oscillatory problems. Here have shown that in present time there are four classes of methods, which can be applied to solve initial-value problem for ODEs. Currently, for solving of the problem (1) has been constructed the new class of methods on the intersection of the specified methods.

And now let us note that the results obtained above can be applied to investigation of initial value problem for Volterra integro-differential equation. The interesting results receive in [39]-[42] for solving Hamiltonian equation.

Conclusion

As is known one of the modern directions in computational mathematics is the construction of stable methods with a higher order of accuracy. As was shown here, for the construction of more exact methods one can be used the presentation of the local truncation error (see for example [15]). Noted that similar schemes were used in the study of the Richardson extrapolation method, and Hamming method, using the linear combination of some methods with the special presentation of local truncation error. Noted that, here using the special presentation of local truncation errors have been constructed the bilateral numerical methods. Using this presentation of local truncation errors has been determined the answer, how much does the accuracy of calculating the value according to the above schemes increases? The theoretical answer to this question can be found in the work [15]. But here the answer to this question was given with the help of illustrations. Here have selected the best options and placed them. By the results obtained here, it can be argued that it is desirable to use hybrid methods since they are more accurate and have an extended stability region.

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Evaluation of Secondary School Mathematics Curriculum in Terms of 21st Century Skills

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Abstract: This research examines the secondary school mathematics curriculum regarding 21st-century skills. The method of the research is document analysis, which is one of the qualitative research designs. The document of the study is the 2018 Turkish Mathematics Lesson Curriculum. At each grade level, learning areas were considered, and the acquisitions were examined. The number of achievements that directly serve the skills of creativity and innovation, critical thinking and problem-solving, communication, and collaboration were calculated. The data of the study were analyzed using the descriptive analysis method. According to the results, no acquisitions directly serve creativity and communication skills at the 5th-grade level. Only one benefit has been identified from direct service to the collaboration skill. Thirteen acquisitions at the 6th-grade level are related to critical thinking and problem-solving skills, and one acquisition is related to creativity skills. There are no acquisitions that directly serve communication and cooperation skills. Thirteen acquisitions at the 7th-grade level are related to critical thinking and problem-solving skills, and one acquisition is related to creativity skills. There is no acquisition in the curriculum that directly serves communication and cooperation skills. Only seven achievements at the 8th-grade level were associated with learning and innovation skills. Three of these achievements are related to creativity, and four are related to critical thinking and problem-solving skills. No acquisitions that directly serve communication and cooperation have been identified in the curriculum. In the mathematics curriculum, encouraging measures were taken, and recommendations were made for developing 21st-century skills. It is thought that teachers, school facilities, and school management will be decisive in gaining these skills.

Keywords: Secondary school mathematics curriculum, 21st-century skills, Descriptive analysis

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Introduction

The concept of change is prevalent today. There is a dizzying pace of change in technology, social life, tourism, accounting, trade, education, and many other fields. For the sustainable competition, it is necessary to keep up with the innovations that come with change. Qualified individuals are needed for the production and service

sector to maintain competitiveness. Qualified individuals have the skills appropriate to the needs of their age. Critical thinking, practical reasoning, innovative thinking, analytical thinking, communication skills, cooperation, and developing cooperation are among the common characteristics of these individuals (Partnership for 21st Century Skills, 2009).

Educational institutions must renew themselves to respond to the new needs that arise with the change. It has been stated that in the 21st century, humanity is facing severe difficulties, especially in the social and economic fields (Bialik & Fadel, 2015). To cope with these difficulties, individuals need to gain the ability to collaborate with groups, argue, reason, and learn together, and co-construct knowledge and technologies (Latifi & Noroozi, 2021; Latifi et al., 2020, 2021; Noroozi 2018, 2022; Noroozi et al., 2012; 2016; 2020; Valero Haro et al., 2019; 2022) and manage themselves (McCoog, 2008). From this point of view, the curriculum of primary, secondary and high school courses has been renewed in Türkiye. Eight key competencies are included in the curriculum within the Turkish Qualifications Framework (MoNE, 2013). These competencies are communication in the mother tongue, communication in foreign languages, mathematical and essential competencies in science/technology, digital competence, learning to learn, social and civic competencies, initiative and entrepreneurship, cultural awareness, and expression. The curriculum aims to raise individuals with the knowledge, skills, and behaviors integrated with the competencies. Students at national and international levels aim to gain the skills they will need in their personal, social, academic, and business lives.

21st Century Learning Framework

Some initiatives have been taken to determine the human profile that society and business life need in the near and far future and to prepare young people for the future. One of these initiatives is the organization known as Partnership for 21st Century Learning (P21), in which public and private institutions also participate. National Education Association (NEA), United States Department of Education, AOL Time Warner Foundation, Apple Computer, Inc., Cable in the Classroom, Cisco Systems, Inc., Dell Computer Corporation, Microsoft Corporation, SAP, Ken Kay, Dins Golder- Institutions and organizations such as Dardis have joined this non-profit organization. The organization brought together the business community, education leaders, and policymakers. It aims to raise awareness with 21st Century skills and to prepare all students for the 21st Century (Murat & Cam, 2021; Partnership for 21st Century Skills, 2009; Rahimi, Shute, & Zhang, 2021; Said & AlHares, 2021).

The P21 organization has identified three main themes: learning & innovation skills, information, media & technology skills, and life & career skills within the 21-century learning framework. The central theme of learning & innovation skills, creativity and innovation, critical thinking and problem-solving, communication, and collaboration skills are included (see Figure 1). These skills are explained in detail in the next step. This study aims to examine at what level the mentioned skills are included in the acquisitions in the secondary school mathematics curriculum in Turkey.

Creativity and innovation: Today, individuals need more creative thinking skills to adapt to changing living conditions. Creative thinking is necessary to find solutions to the problems encountered and to adapt to the environment. Creativity has been associated with concepts such as developing an idea (Emanuel & Challons-Lipton, 2012), usefulness (Runco, 2007), producing an original product (Akca & Kavak, 2021; Treffinger & Isaksen, 2005), and producing solutions to problems (Daher & Anabousy, 2020; Nickerson, 1999). In addition, creative thinking is associated with discovering new ways, establishing new relationships, or developing solutions (Bicer, 2021; Cropley, 2001; Sarıkaya & Deniş-Çeliker, 2022). In addition, it has been stated that creative thinking is also related to behaviors such as curiosity, making inventions, making synthetic judgments, thinking with images, experimenting, and researching (San, 2004). Being sensitive to and recognizing problems, developing and testing hypotheses for problems, and sharing solutions developed for problems are common characteristics of creative thinkers (Torrance, 1965). Individuals need to be sensitive to different perspectives, open to arguments from other positions (Taghizadeh Kerman et al., 2022), understand how new ideas can be adapted to the real world, and limit originality and creativity in their work. The knowledge or products produced should be used in their field without fear and with great courage to make a tangible and valuable contribution (Partnership for 21st Century Skills, 2009).

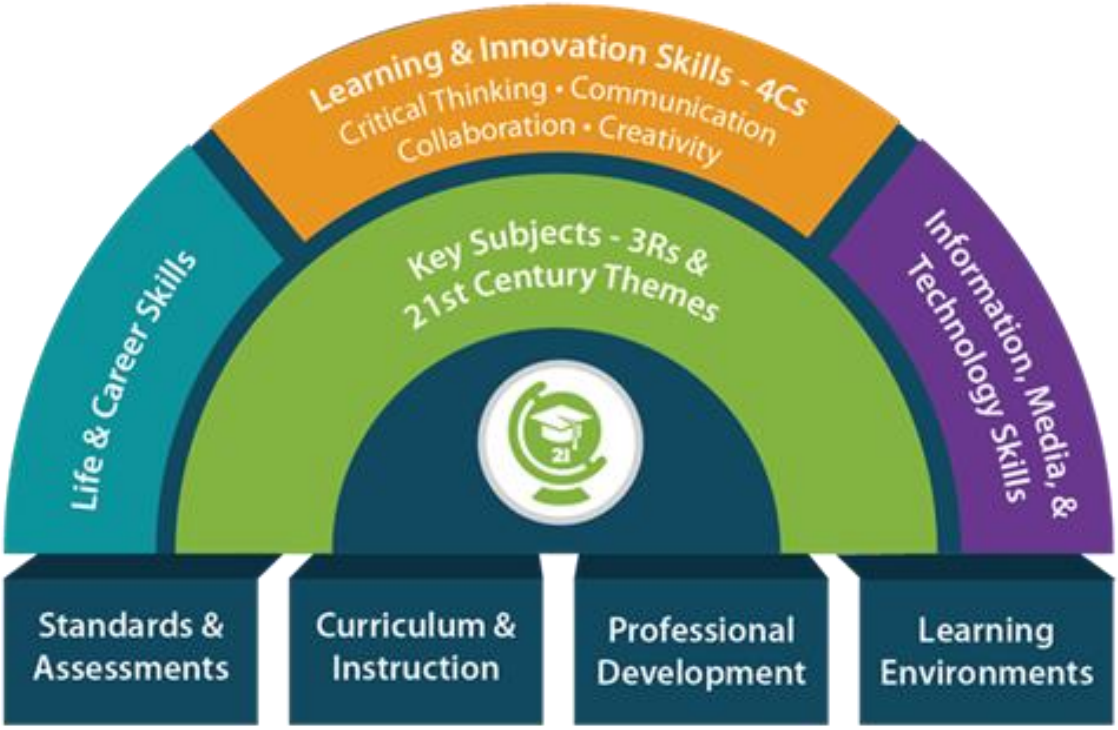

Figure 1. Framework for 21st Century Learning (Resource: http://www.p21.org)

Critical thinking and problem-solving are among the high-level thinking skills. Critical thinking means making a balanced judgment after examining previous experiences, knowledge, and thoughts and, evaluating different views, and looking at a subject or event with a logical eye (Nosich, 2018) and, questioning a situation or event with healthy skepticism, evaluating it within the framework of specific criteria, and making an evidence-based

judgment require critical thinking (Çakan Akbaş, 2021). Evaluating the extent to which a result is reasonable or confirmed by evidence and reaching conclusions based on observation and knowledge is possible with critical thinking (Paul, 1991). On the other hand, problem-solving can be defined as a cognitive-behavioral process created by individuals to find effective ways to cope with the distressing situations they encounter daily. Individuals with problem-solving skills try to understand the problem, produce a solution, use appropriate techniques and operate the control mechanism.

Communication is the process of expressing one's feelings and thoughts clearly and effectively in writing and verbally. In other words, communication is the exchange of emotions, thoughts, behaviors, and information between two people or groups of people in the position of sender and receiver (Milner, 1989). Individuals with communication skills know how to listen and use body language effectively. They can communicate openly, give a motivational speech, learn how to persuade individuals, and develop empathy skills.

Collaboration: It is a process in which employees in an organization come together to solve some common problems, exchange views, and act together to solve existing problems. In this process, the parties understand each other's needs, interests, and difficulties, and they tend to show skills such as making concessions, acting flexibly, working voluntarily, and taking responsibility to achieve the common goal. The training manager who needs to work in cooperation should demonstrate the following skills (Partnership for 21st Century Skills, 2009): a) Demonstrating the ability to work effectively and respectfully with different teams, b) Providing the flexibility, willingness, and assistance necessary to achieve the common goal, c) Partner knowing how employees will share their responsibilities in work and how much each team member will contribute.

In studies conducted in Turkey, Turkish lessons (Aydın & Tunagür, 2021; Boyacı & Özer, 2019; Bal, 2018; Kayhan, Altun & Gürol, 2019; Kurudayıoğlu & Soysal, 2018), English lesson (Çelebi & Altuncu, 2019) In this study, pre-(Kardeş, 2020) curricula were examined in the context of 21st century skills. This research aims to examine how much the learning & innovation skills determined by P21 are included in the acquisitions in the secondary school mathematics curriculum in Turkey. Accordingly, answers to the following research questions were sought:

1- How many learning & innovation skills are included in the learning outcomes in the 4th-grade mathematics curriculum?
2- How many learning & innovation skills are included in the learning outcomes in the 5th-grade mathematics curriculum?
3- How many learning & innovation skills are included in the learning outcomes in the 6th-grade mathematics curriculum?
4- How many learning & innovation skills are included in the learning outcomes in the 7th-grade mathematics curriculum?

Method

Research Model

This research aims to evaluate the secondary school mathematics curriculum within the framework of 21st-century skills. The method of the research is document analysis, which is one of the qualitative research designs. Qualitative research; These are studies that follow a process to reveal perceptions and events realistically in a natural environment by using data collection methods such as observation, interview, and document analysis. Document review includes analyzing written materials containing information about the case or cases to be investigated (Berg & Lune, 2019).

Data Collection Tool

Documents were used as a data collection tool. The document of the study is the 2018 Turkish Mathematics Lesson Curriculum. Document analysis is a comprehensive analysis of written tools or documents containing information about the phenomenon targeted to be investigated.

Data Analysis

In this study, the study's data were analyzed using the descriptive analysis method. The descriptive analysis method is used because the themes are predetermined. The predetermined themes of this research are 21st-century skills. Within the 21-century learning framework, three main themes were identified: learning & innovation skills, information, media & technology skills, and life & career skills.

The central theme of learning & innovation skills, creativity and innovation, critical thinking and problem-solving, communication, and collaboration skills are included. In this study, only the skills in the central theme of Learning & innovation skills were taken into account, and the achievements in the mathematics curriculum were examined.

The results were interpreted using the descriptive analysis method. The data obtained from the descriptive analysis are interpreted and summarized according to the previously determined themes. The purpose of such analysis is to present the findings to the reader in an organized and interpreted form. Thus, the data obtained are first described logically and understandably, then these descriptions are interpreted, cause-effect relationships are examined, and some conclusions are reached (Yıldırım & Şimşek, 2000).

Learning areas were considered at each grade level, and achievements were examined. The number of achievements that directly serve the skills of creativity and innovation, critical thinking and problem-solving, communication, and collaboration were calculated.

Results

There are three learning areas: numbers and operations, geometry and measurement, and data processing learning in the fifth-grade curriculum of the secondary school mathematics course. A total of 56 acquisitions were included at the fifth-grade level. The distribution of the fifth-grade achievements serving 21st-century learning and innovation skills is shown in Table 1.

Table 1. Distribution of Fifth Grade Outcomes Related to Learning and Innovation Skills

Learning and Innovation Skills	5th grade			
	Learning domain			Total
	Numbers and operations	Geometry and measurement	Data processing	
Creativity	0	0	0	0
Critical thinking & problem-solving	6	3	1	10
Communication	0	0	0	0
Collaboration	0	0	1	1
Total	6	3	2	11

When Table 1 is examined, it is understood that six acquisitions in learning numbers and operations are related to critical thinking and problem-solving skills. Some identified outcomes are as follows: "Compares a natural number with a composite fraction" and "Solves and sets up problems that require addition and subtraction operations with fractions whose denominators are equal or the denominator of one is a multiple of the denominator of the other."

It has been determined that three acquisitions in geometry and measurement are related to critical thinking and problem-solving skills. Some of the determined gains are as follows: "Recognizes time measurement units, convert them to each other, and solves related problems." and "Solves problems that require calculating the surface area of a rectangular prism."

It was determined that achievement in data processing learning was related to critical thinking and problem-solving skills, and another achievement was related to cooperation skills. Some determined gains are as follows: "Recognizes time measurement units, converts them to each other, and solves related problems." and "Creates research questions that require data collection." In the curriculum, while the research questions are created to explain the achievements, environmental awareness, thrift, cooperation, avoidance of waste, etc., topics should be included.

There are four learning areas in the sixth-grade middle school mathematics course: numbers and operations, algebra, geometry and measurement, and data processing learning. A total of 59 acquisitions were included at the sixth-grade level. The distribution of sixth-grade achievements serving 21st-century learning and innovation skills is shown in Table 2.

Table 2. Distribution of Sixth Grade Outcomes Related to Learning and Innovation Skills

Learning and Innovation Skills	6th grade				
	Learning domain				
	Numbers and operations	Algebra	Geometry and measurement	Data processing	Total
Creativity	1	0	0	1	1
Critical thinking & problem-solving	5	0	8	0	13
Communication	0	0	0	0	0
Collaboration	0	0	0	0	0
Total	6	0	8	1	14

When Table 2 is examined, it is understood that thirteen acquisitions are related to critical thinking and problem-solving skills, and one acquisition is related to creativity skills. There are no acquisitions that directly serve communication and cooperation skills. Some of the identified achievements are as follows: "Solves and sets up problems that require four operations with natural numbers." and "Compares, sorts, and displays fractions on the number line." In the explanation of the second outcome, which is presented as an example, there is an explanation that "while determining the strategies to be used in ordering fractions, students are first allowed to create their strategies." In this way, students' creative thinking skills were supported.

There are four learning areas in the seventh-grade middle school mathematics course: numbers and operations, algebra, geometry and measurement, and data processing learning. A total of 48 achievements were included at the seventh-grade level. The distribution of seventh-grade achievements serving 21st-century learning and innovation skills is shown in Table 3.

Table 3. Distribution of Seventh Grade Outcomes Related to Learning and Innovation Skills

Learning and Innovation Skills	7th grade				
	Learning domain				
	Numbers and operations	Algebra	Geometry and measurement	Data processing	Total
Creativity	0	1	0	0	1
Critical thinking & problem-solving	8	2	3	0	13
Communication	0	0	0	0	0
Collaboration	0	0	0	0	0
Total	8	3	3	0	14

When Table 3 is examined, it is understood that thirteen acquisitions are related to critical thinking and problem-solving skills, and one is related to creativity skills. A large proportion of the identified achievements are in learning numbers and operations. There is no acquisition in the curriculum that directly serves communication and cooperation skills. Some of the identified achievements are as follows: "Solves problems that require operations with integers.", "Decides whether two multiplicities are proportional by examining real-life situations" and "Solves problems with direct and inverse proportion."

The eighth-grade secondary school mathematics curriculum has five learning areas: numbers and operations, algebra, geometry and measurement, data processing, and probability learning. A total of 52 learning outcomes were included at the eighth-grade level. The distribution of eighth-grade achievements serving 21st-century learning and innovation skills is shown in Table 4.

Table 4. Distribution of Eighth Grade Outcomes Related to Learning and Innovation Skills

	8th grade					
	Learning domain					
Learning and Innovation Skills	Numbers and operations	Algebra	Geometry and measurement	Data processing	Possibility	Total
Creativity	0	2	1	0	0	3
Critical thinking & problem-solving	0	1	2	1	0	4
Communication	0	0	0	0	0	0
Collaboration	0	0	0	0	0	0
Total	0	3	3	1	0	7

When Table 4 is examined, it has been observed that seven acquisitions are related to learning and innovation skills. Three of these achievements are related to creativity, and four are related to critical thinking and problem-solving skills. No gains that directly serve communication and cooperation have been identified in the curriculum. Some of the identified achievements are as follows: "Creates and interprets equations, tables, and graphs of real-life situations with linear relationships.", "Writes mathematical sentences suitable for daily life situations involving inequality with a first-degree unknown" and "Creates the Pythagorean relation and solves the related problems.", "Displays data as a column, circle, or line graph and makes appropriate conversions between these representations." The explanation "The advantages and weaknesses of different representations are emphasized" is included in the explanation of the acquisition in the field of data processing learning. In this context, it is aimed to support students' critical thinking skills.

Conclusion and Recommendations

This research examines the secondary school mathematics curriculum in terms of 21st-century skills. According to the results, no acquisitions directly serve creativity and communication skills at the 5th-grade level. Only one benefit has been identified from direct service to the collaboration skill. It is understood that thirteen acquisitions at the 6th-grade level are related to critical thinking and problem-solving skills, and one acquisition is related to creativity skills. There are no acquisitions that directly serve communication and cooperation skills. It is understood that thirteen acquisitions at the 7th-grade level are related to critical thinking and problem-solving skills, and one acquisition is related to creativity skills. A large proportion of the identified achievements are in learning numbers and operations. There is no acquisition in the curriculum that directly serves communication and cooperation skills. It was observed that only seven achievements at the 8th-grade level were associated with learning and innovation skills. Three of these achievements are related to creativity, and four are related to critical thinking and problem-solving skills. No gains that directly serve communication

and cooperation have been identified in the curriculum.

Although some achievements are not directly related to creativity, critical thinking, communication, and cooperation, they may indirectly contribute to developing these skills, depending on the strategy, method and technique the teacher will use to transfer these gains. For example, for an outcome that requires problem-solving, the teacher's forming groups in the classroom and encouraging students to share their views will enable the development of cooperation and communication skills. Again, while conveying the achievements, the teacher's asking open-ended questions in the lesson can enable the student to think deeply and question. In this way, the development of critical thinking skills can be achieved. As a result, encouraging measures were taken, and recommendations were made in the program for developing 21st-century skills. It is thought that teachers, school facilities, and school management will be decisive in gaining these skills.

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Construction of Some Algorithm for Calculation of Definite Integrals by Using Advanced and Hybrid Methods

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Abstract: As is known one of the well-researched mathematical problems is the initial-value problem for the ODEs. There are some classes of methods for solving this problem. The present time has been constructed the new classes of methods of advanced and hybrid types. By using these methods have been constructed the class of methods on the intersection of the above-mentioned methods. Recently, many professionals try to construct simple methods having a high order of accuracy. By taking this into account, many scientists investigate the application of the above-mentioned methods, to solve problems that differ from the initial-value problem for ODEs. Here also considered the possibility of applying methods to solving Volterra integral and integro-differential equations. And also, here has investigated construction the efficient methods for calculation of definite integrals. For this aim, has used the multistep methods of advanced and hybrid types with special structures. Given some comparison constructed, here methods with the known, as Gauss, Adams and etc. For the illustration of the theoretical results received here, have considered the application of symmetrical methods and simple advanced methods to solve some model problems. Have shown that the receiving results correspond to theoretical.

Keywords: Initial-Value Problem, Ode, Volterra Integral and Integro-Differential Equations, Multistep Methods with Constant Coefficient, Advanced and Hybrid Methods, Symmetrical Methods

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Introduction

As is known the first direct numerical method for solving initial-value problem of ODEs has been constructed in the XVIII century by Euler's (see for example [1], [2]). This method have been successfully applied to solve of ODEs. Noted that it is successfully used in solving initial value problem for ODEs and in the present time. As is known in the development of Euler methods are arises one step and multistep methods, famous representatives for are Runge-Kutta methods and Adams-Moulton and Adams Bashforth methods. As is known, by the generalization of Adams-Moulton and Adams-Bashforth methods in the XX sentry appeared multistep methods with constant coefficients. This method has investigated by many known scientists (see for example [3]-[5]). Noted that multistep method fundamentally have investigated by Dahlquist. He has published his famous work dedicated to investigation following problem (see for example [6]-[9]):

$$y' = f(x, y), \quad y(x_0) = y_0, \quad x_0 \le x \le a, \tag{1}$$

by using the multistep methods presented in the form:

$$\sum_{i=0}^{k} \alpha_i y_{n+i} = h \sum_{i=0}^{k} \beta_i f_{n+i} \qquad (n = 0,1,2,...). \tag{2}$$

Here the coefficients $\alpha_i, \beta_i \quad (i = 0,1,2,...,k)$, are some real numbers, k – is integer, $f_m = f(x_m, y_m) \quad (m = 0,1,2,...)$, x_i - are mesh pointes which have determined in the form $x_{i+1} = x_i + h \quad (i = 0,1,2,...)$, $0 < h$ - is step-size. And by y_m - denoted the approximately values of the solution of the problem (1) at the point x_m, but the corresponding exact values of the solution of the problem (1) denoted by the $y(x_m) \quad (m = 0,1,2,...).$ And also suppose that the given function of $f(x, y)$ is continues to totality of arguments and has defined in some close domain. Dahlquist investigated method (2) and prove that the conception of stability for method (2) is a necessary and sufficient condition for it's convergence. This condition was established with other scientists (see for example [10]-[14]). Given the above result Dahlquist prove that if the method of (2) is stable, then it's degree satisfies the condition

$$p \le 2[k/2] + 2,$$

and for each value of k there are stable methods with the degree $p_{\max}$ for $\alpha_k \ne 0$ and $\beta_k \ne 0$. In the case $\alpha_k \ne 0$ and $\beta_k = 0$ for all the values of k there are stable methods with the degree of $p_{\max} = k$. Here the conceptions of stability and degree for the method (2) are determine as following (see for example [7]):

Definition 1. The integer p call as the degree for the method (2) if the following asymptotic equality is satisfies:

$$\sum_{i=0}^{k} (\alpha_i y(x+ih) - h\beta_i y'(x+ih)) = O(h)^{p+1}, \quad h \to 0 \quad (p \ge 0). \tag{3}$$

Definition 2. Method (2) is call as the stable, if the roots of the characteristics polynomial $\rho(\lambda)=\alpha_k\lambda^k+\alpha_{k-1}\lambda^{k-1}+...+\alpha_k\lambda+\alpha_0$ are located in the unit circle on the boundary of which there are not multiply roots.

Noted that Bakhvalov in 1955 y. has received the following result: $p\le k$ takes place for stable explicit methods of type (2) if $k\le 10$ (see [15]). From here receive that the Dahlquist's result is more general, but the maximum degree for stable methods receiving from the method (2) is low. Therefore, it became necessary to constructed methods with high accuracy. For this aim, himself Dahlquist proposed to use the following method

$$\sum_{i=0}^{k}\alpha_i y_{n+i}=h\sum_{i=0}^{k}\beta_i f_{n+i}+h^2\sum_{i=0}^{k}\gamma_i g_{n+i}, \tag{4}$$

here the function $g(x,y)$ has defined as following:

$$g(x,y)=f_x^{'}(x,y)+f_y^{'}(x,y)f(x,y).$$

From here it can be seen that the computational work in using of the method (4) is increases. Method (4) was investigated as numerical method for solving problem (1) and the following:

$$y''(x)=F(x,y(x),y'(x)),\ y(x_0)=y_0,\ y'(x_0)=y_0^{'},\ x_0\le x\le X. \tag{5}$$

For the application method (4) to solve the problem (5), it can be written as:

$$\sum_{i=0}^{k}\alpha_i y_{n+i}=h\sum_{i=0}^{k}y_{n+i}^{'}+h^2\sum_{i=0}^{k}\gamma_{n+i}^{''}.$$

For the calculated of the values $y_{n+i}^{'}$ one can be used the following method:

$$\sum_{i=0}^{k}\alpha_i^{'}y_{n+i}^{'}=h\sum_{i=0}^{k}\beta_i^{'}y_{n+i}^{''}. \tag{6}$$

Dahlquist for the definition the maximum value of the stable methods receiving from the (4), prove the following theorem.

Theorem. Let the method (4) has the degree of p. Then there exist the stable methods with the degree

$$p\le 2k+2,$$

and there are stable methods with the maximum degree for all the values of k.

Method (2) and (4) has investigated by many authors (see for example [13]-[28]).

Application of Advanced Methods to Calculating of Definite Integrals

As was mentioned above the maximum value of degree for the multistep method (2) define as: $p_{\max} = 2k$. But this bounder for the stable methods of type (2) can be written as: $p_{\max} = 2[k/2]+2$. For the construction more exact methods of type (2), let us to consider the following method, which can be receive from the method (2) as partial case:

$$\sum_{i=0}^{k-m} \alpha_i y_{n+i} = h\sum_{i=0}^{k} \beta_i f_{n+i} \quad (m>0). \tag{7}$$

This method resembles the method of Cowell. Noted that some known scientists as Laplas, Steklov and etc. (see for example [29]) have constructed the stable methods of type (7) with the degree $p \le 2[k/2]+2$. It is not difficult to understand that application of the methods of type (7) to solve some problems more difficult than the application of the method (2) and the maximum value for the degree of constructed stable methods of type (7) have obeyed the laws of Dahlquist. By taking this into account the specialists developed methods of type (2). The advantages of the methods receiving from the (7) have proved in [14], and constructed stable advanced method of type (7) for $k=3$ and $m=1$ with degree $p_{\max}=5$. As is known for the value $k=3$, from the method of (2) one can receive stable method with the degree $p_{\max}=4$. It follows from here that the method (7) is more accurate. By using this property of advanced methods have constructed the special predictor-corrector methods for application of advanced methods of type (7) to solve problems of type (1). Noted that these predictor-corrector methods can be applied to solve Volterra integral and integro-differential equations and also to calculation of definite integrals. To illustrate what was said, let us to consider the following specific method:

$$y_{n+1} = y_n + h(8y'_{n+1} + 5y'_n - y'_{n+2})/12, \tag{8}$$

which is stable and has the degree $p=3$. If applied this method to solve problem (1), then receive:

$$y_{n+1} = y_n + h(8f_{n+1} + 5f_n - f_{n+2})/12. \tag{9}$$

It follows from here that, for the calculation the value of y_{n+1} by the method (9) it should be known the value f_{n+1} and f_{n+2}. But the calculation of the values f_{n+1} and f_{n+2} depends from the values y_{n+1} and y_{n+2}. For the calculation of these values, here have proposed to use predictor-corrector method constructed in the following form:

$$\hat{y}_{n+1} = y_n + hf_n; \tag{10}$$

$$\bar{y}_{n+1} = y_n + h(\hat{f}_{n+1} + f_n)/2. \tag{11}$$

But for the calculation of the value $\bar{y}_{n+2}$ one can be used the following sequences of methods,

$$\hat{y}_{n+2} = \bar{y}_{n+1} + h\bar{f}_{n+1},$$

$$\bar{y}_{n+2} = \bar{y}_n + h(\hat{f}_{n+2} + \bar{f}_{n+1})/2.$$

These methods one of the same with the methods (10) and (11). Noted that method (9) has the degree $p = 3$, but methods (10) and (11) has the degree of $p = 1$ and $p = 2$, respectively (method (10) is explicit Euler, but the method (11) is trapezoidal method).

As was proved in [10] if in the method of (9) used the values $\bar{y}_{n+1}$ and $\bar{y}_{n+2}$ calculated by the trapezoidal rule, then the accuracy of the method (9) is preserved.

And now let us to consider application of advanced methods to calculation of definite integral

$$I = \int_{x_0}^{b} \varphi(s)ds \tag{12}$$

For the simplicity let us to consider application of the following advanced method to calculation of definite integral (12):

$$\sum_{i=0}^{s} \alpha_i y_{n+i} = h\sum_{i=0}^{k} \beta_i f_{n+i}\ . \tag{13}$$

From this method it follows method (7) as the partial case ($s = k - m; m > 0$). And method (2) also can be receive from the method (7) as the partial case $m = 0$.

The maximal value for the degree of the stable method of type (7) can be written as: $p_{\max} = k + m + 1$ if $k \geq 3m$. Method with the degree $p = k + m + 1$ for the $k = 3$ and $m = 1$ can be presented in the following form:

$$y_{n+2} = (8y_{n+1} + 11y_n)/19 + h(10f_n + 57f_{n+1} - f_{n+3})/57 \tag{14}$$

Local truncation error for this method can be written in the following form:

$$R_n = -11y_n^{(6)}/3420 + O(h^7).$$

It is not difficult to define that for the application of method (7) to calculation of following definite integral the linear part of which must be presented as:

$$y_{n+k-m} = y_n + h\sum_{i=0}^{k} \beta_i \varphi_{n+i} \ . \tag{15}$$

By using presentation of definite integrals receive that in this case the function $\varphi(x)$ independent from the function of $y(x)$. Therefore, in this case are not arises the necessarty for the calculation of the values $y(x_j)\ (j \geq n+k-1)$ (see application of method (23)). In this case the maximum value of the degree for the method (2) will satisfy the condition $p \leq k+2$. From here receive that it is desirable to apply method (7) to calculation definite integral of (12). In this case receive the following initial value problem:

$$y'(x) = \varphi(x),\ \ y(x_0) = y_0,\ \ x_0 \leq x \leq b\,. \tag{16}$$

If compare the problems (1) and (31), then receive that in the application of the implicit, advanced and hybrid methods to solving problem (31) are not arises any difficulties, but to contrary application of above named methods to solve problem (1) arises some difficulties related with the calculation of the determine of the values $y_{n+k-m}, y_{n+k-m+1,\ldots,}y_{n+k}$. But for the objectivity noted that for the calculation the value y_{n+k} by the advanced methods arises the necessity to using the values of the solution at the pointes $x_{n+k+j}\ (j>0)$, which are outside of the segment in which investigated the problem (1). And in the application of hybrid methods are also arises some difficulties related with the calculating of the values of the solution for the problem (1) at the hybrid points. Thus receive that all the numerical methods has its own advantages and disadvantages. For the correction some of disadvantages of advanced methods here suggested some ways by using predictor-corrector methods.

Noted that one of advantage of the advanced methods is using more information about the solution of investigated problem. For the demonstration these let us compare the methods (9) and (11). In the application of the method (9) have used the values of the solution of the investigated problem at three mesh points (at previous, current and at next), but in the trapezoidal rule (11) are used the values of the solution of investigated problem at previous and the current mesh points. For the obtaining reliable information about the meaning of the solution to the problem under study, in usually are used bilateral methods. Therefore let us consider the following section.

About One Way to Construct Bilateral Methods

For the illustration of advantages of bilateral methods to consider the Euler's methods, which can be receive by the discarding the local truncation error in the following equalities:

$$\overline{y}(x_{n+1}) = \overline{y}(x_n) + hf\,(x_n, \overline{y}(x_n)) + \frac{h}{2!}\overline{y}\,''(x_n) + O(h^3),$$

$$y(x_{n+1}) = y(x_n) + hf\,(x_{n+1}, y(x_{n+1})) - \frac{h}{2!}y''(x_n) + O(h^3)\,.$$

If suppose that $\bar{y}(x_n) = y(x_n)$ and $y''(x) \geq 0$, then from here by using $\bar{y}(x_{n+1}) = y(x_{n+1})$ receive that (see [30]-[31]):

$$\bar{y}_{n+1} < y(x_{n+1}) < y_{n+1}, \tag{17}$$

here $\bar{y}_{n+1}$ and y_{n+1} is the approximately values of the solution of investigated problem at the point x_{n+1}.

Noted that from the estimation of (16) it is not follow that the following methods can be taken as the bilateral method:

$$\bar{y}_{n+1} = \bar{y}_n + hf(x_n, \bar{y}(x_n)); \quad y_{n+1} = y_n + hf(x_{n+1}, y_{n+1}).$$

For the bilateral methods the estimation of (17) should be done for all the values of n (see [31]). Therefore the Euler's methods can be taking as the bilateral formulas for the construction of bilateral methods. One can be constructed the bilateral methods by using the methods with fructional step-size. For the illustrution of this let us to consider following equalities:

$$y(x_{n+1}) = y(x_n) + h(f(x_{n+1}, y(x_{n+1}) + 3f(x_{n+1/3}, y(x_{n+1/3}))/4 - h^4 y^{(IV)}_{x_n}/216 + O(h^5), \tag{18}$$

$$y(x_{n+1}) = y(x_n) + h(f(x_n, y_n) + 3f(x_{n+2/3}, y(x_{n+2/3}))/4 + h^4 y^{(IV)}_{x_n}/216 + O(h^5). \tag{19}$$

$$y_{n+1} = y_n + h(f_{n+1} + 3f_{n+1/3})/4; \tag{20}$$

$$y_{n+1} = y_n + h(f_n + 3f_{n+2/3})/4. \tag{21}$$

Each of these methods has a degree $p = 3$.

It is not hard to define that half-sum of the values of the calculated by the methods will be more accurate than the values calculated by the methods receving from the equalities (18) and (19) by the discripting of the errors.

The method receiving in the results of using half-sum of the methods (20) and (21) can be written as:

$$y_{n+1} = y_n + h(f_n + 3f_{n+1/3} + 3f_{n+2/3} + f_{n+1})/8. \tag{22}$$

Local truncation error for this method can be presented as follows:

$$R_n = 49h^5 y^{(V)}(x_n)/3240 + O(h^6).$$

It is not difficult to determine that method (22) is one step method. Let us compares this method with corresponding Runge-Kutta method. For this aim, let to consider the following Runge-Kutta method with the 4-th order:

$$y_{n+1} = y_n + h(k_1^{(n)} + 3k_2^{(n)} + 3k_3^{(n)} + k_4^{(n)})/8, \tag{23}$$

here the values k_1, k_2, k_3 and k_4 defined as follows:

$$k_1 = f(x_n, y_n);\ k_2 = f(x_n + h/3,\ y_n + hk_1^{(n)}/3);$$
$$k_3 = f(x_n + 2h/3,\ y_n - hk_1^{(n)}/3 + hk_2);$$
$$k_4 = f(x_n + h,\ y_n + h(k_1 - k_2 + k_3)).$$

Noted that methods (22) and (23) are the one step methods and method (22) is the implicit, but the method (23) is explicit. These methods have the one and the same order of accuracy. Hence the use of method (22) is more difficult than the method (23). But using predictor-corrector method can get rid of the indicated disadvantage of method (22). Noted that the results obtained by the implicit method are better than the results obtained by the explicit methods. Therefore method (22) can be taken as the better. But in the application of method (22) arises some difficulties with the finding the solution of nonlinear equation. Noted that, similarly difficulties are arises in using implicit methods independent from its representation. Noted that application of the method (22) depends from the calculation of the values $y_{n+1/3}, y_{n+2/3}$ and y_{n+1}. For the calculation of these values suggested, here to use explicit Euler and trapezoid methods. For example to calculation of the value $y_{n+1/3}$, one can be used the following predictor-corrector method:

$$\hat{y}_{n+1/3} = y_n + hf(x_n, y_n)/3,$$
$$y_{n+1/3} = y_n + h(f(x_n, y_n) + f(x_{n+1/3}, \hat{y}_{n+1/3}))/6.$$

For receiving the more accurate results, to above used predictor-corrector method can added the method of (22). By using described way receive that the calculation of the values $y_{n+1/3}, y_{n+2/3}$ and y_{n+1} are not difficult. Therefore it is advisable to use in first methods (22), (23) and then used method of (22).

It is not difficult to presented method (22) as multistep method. In this case receive the following method:

$$y_{n+3} = y_n + 3h(f_n + 3f_{n+1} + 3f_{n+2} + f_{n+3})/8. \quad (24)$$

This method is three step method, stable and has the degree $p = 4$. If are known the value y_n, y_{n+1} and y_{n+2} then by using method (24) one can be calculated the values y_m $(m = n+3, n+4, ...)$. And in this case receive that at each step the function $f(x, y)$ will be calculated one or two times. But in the application method (23) at each step the function $f(x, y)$ will be calculated 4-times. By simple comparison methods (22) and (23) receive that hybrid methods are the better than the others. Noted that by using Dahlquist result receive that maximum value for the degree of the three step methods equal to $4\,(p_{\max} = 4)$. Therefore by using some operation, it is not available to increase the maximum value of the degree for the method (24). And now let us consider following Runge-Kutla method of the second order:

$$y_{n+1} = y_n + h(k_1^{(n)} + 3k_2^{(n)})/4, \quad (25)$$

here $k_1^{(n)} = f(x_n, y_n),\ \ k_2^{(n)} = f(x_n + 2h/3,\ y_n + 2hk_1^{(n)}/3)$.

This method reminds us the method of (21). If to use Euler explicit method, then one can be written:

$$k_2^{(n)} = f(x_n + 2h/3,\ y_{n+2/3}) \text{ or } k_2^{(n)} = f_{n+2/3} = y'_{n+2/3}.$$

By using the receiving in the method of (25) have the following:

$$y_{n+1} = y_n + h(f(x_n, y_n) + 3f(x_n + 2h/3,\ y_{n+2/3}))/4,$$

which is the same as the method of (21). Method (21) has the degree $p = 3$, but the method (25) has the degree $p = 2$. For solving this problem have decided to investigate the family of the Runge-Kutta methods of 3-d degree and found the following:

$$y_{n+1} = y_n + h(k_1^{(n)} + 3k_3^{(n)})/4, \tag{26}$$

here

$$k_1^n = f(x_n, y_n);\ \ k_2^n = f(x_n + h/2,\ y_n + hk_1^{(n)}/3);$$
$$k_3^{(n)} = f(x_n + 2h/3,\ y_n + 2hk_2^{(n)}/3).$$

Thus prove that methods (21) and (26) can be taken one and the same. But methods (21) and (25) are not identity.

Above described scheme receive that there are some direct relation between of the methods of Runge-Kutta and multistep method of hybrid type, some of which have shown in the [32]. Applying the above scheme to similar research of the method (14) can be found some relation between of the methods (14) and Runge-Kutta. Here also have given some comparison between of the one step and multistep methods with the frictional step size. Have shown that methods with the frictional step-size gives the best results.

Remark

In the work [33]-[38] are constructed the symmetric methods, which have applied to solve of Volterra integral equations with symmetric boundaries. And in the works [20] and [33] have constructed the symmetric methods which have applied to solve Volterra integral equations and have given some comparison with the results receiving by the advanced methods. By taking into account that the construction simple methods to calculation of definite integrals is one of the popular problems in modern natural sciences, in [39]-[43] have considered to construction methods with improved properties that were applied to solve popular problems like as the Schrodinger and Duffing equations, orbital and oscillatory problems. Have shown that in present time there are four class of methods, which can applied to solve initial-value problem for ODEs. Currently for solving of the problem (1) has constructed the new class of methods on the intersection of the specified methods.

And now let us show that the results obtained above can be applied to investigation of initial value problem for Volterra integro-differential equation.

Numerical Results

For the illustration the received, here results for the methods (20) and (21), those have applied to solve the following example:

$$y' = \lambda y - t(1-\exp(-\lambda x)) + t\lambda \int_0^x \frac{ds}{y(s)}, \qquad y(0) = 1, \quad 0 \le s \le x \le 1. \tag{27}$$

The exact solution of this problem can be presented as $y(x) = \exp(\lambda x)$.

It is easy to understand that for the application of the methods (20) and (21) to solve the problem (27) arises some difficulties related with the finding the values, $y_{n+1/3}$ and $y_{n+2/3}$, and also y_{n+1} - as the predictor value. Here for the finding the named values are used some explicit method. In our case proposed to use Euler explicit method as the predictor and trapezoidal rule as the corrector method. Here to consider two cases, in first for the calculation of the above named values have used only Euler explicit method, but for the receiving the more exact results have used Euler method with the trapezoidal rule as the predictor-corrector method. For the comparison these results with results receiving by some known methods, here have proposed to use the advanced method of (9).

Local truncation error for the method (9) can be presented the following form:

$$R_n = h^4 y_n^{IV} / 24 + O(h^5).$$

Noted that depends from the methods applied to calculation of the value y_{n+2}, method (9) can be change its properties. For example, if to use the formula: $y_{n+2} = y_{n+1} + h(3f_{n+1} - f_n)/2$ in the method of (9), then in the resulting of which the method will be A – stable (see for example [30]).

The receiving all the results have tabulated in the table 1. Let us noted that the degree for all the methods equal to 3 (p=3).

Table 1. Results for Step-Size h=0.01.

x	M (21)+E	M (21)+Tr	M (20)+E	M (9)+E	M (9)+E
0.1	1.8E-06	4.5E-09	4.5E-09	4.5E-09	1.8E-06
0.3	5.1E-07	1.2E-09	1.2E-09	1.2E-09	5.1E-07
0.5	8.6E-07	2.1E-09	2.1E-09	2.1E-09	8.6E-07
0.8	1.4E-06	3.5E-09	3.5E-09	3.5E-09	1.4E-06
1.0	4.4E-05	1.1E-07	1.1E-07	1.1E-07	4.4E-05

Here have used denotation M (21)+E (Method (21) With the Euler method), but M (21)+Tr (method (21) With the Trapezoidal rule).

From the results tabulated in the table 1, receive that, the exactness of all the methods depends from the exactness of predictor methods. One of the popular numerical method is the multistep method with constant coefficients. In this class methods there are stable methods with the degree $p \le k+2$. For the construction of more exact methods, here proposed to use advanced and hybrid methods, by taking into account that these methods are more exact. These methods as the other methods has its advantages and disadvantages. Here have defined the disadvantages of these methods and given some recombination for its application to solve some practical problems.

Noted that example (27) is the initial value problem for Volterra integral equations if $t \neq 0$. In the case $t = 0$ from the example (27) follows the initial value problem for ODE of the first order.

For the demonstration of the advantages of hybrid methods let us applied the method following method

$$y_{n+1} = y_n + h(f_{n+\nu_0} + f_{n+\nu_1})/2, \quad \nu_0 = 1/2 - \sqrt{3}/6, \quad \nu_1 = 1/2 + \sqrt{3}/6 \tag{28}$$

to solve problem (27) for the case $t = 0$ and for initial value $y(1) = \exp(\lambda)$. It is known that the degree of this method receive the maximum value $p = 4$.

Let us applied this method with midpoint rule to solve problem (27). Results receiving by these methods has tabulated in the table 2 – table 3. In the application of midpoint rule has used the Euler explicit method as the predictor method, but midpoint rule has used as the corrector method. Noted that as the value of y_i in the following midpoint rule

$$y_{i+1} = y_i + hf(x_i + h/2, y_{i+1\backslash 2}),$$

has used the values calculated by the methods (21).

Table 2. Results Receiving for the Values $h = 0.05$.

x	$\lambda = 1$		$\lambda = -1$	
	Method (28)	Trapezoidal rule	Method (28)	Trapezoidal rule
1.1	1.0E-8	6.0E-5	1.2E-9	7.2E-6
1.4	5.7E-8	8.1E-5	3.5E-9	5.3E-6
1.7	1.3E-7	1.0E-4	4.6E-9	3.5E-6
2.0	2.6E-7	1.4E-4	4.9E-9	2.9E-6

By the results tabulated here, one can be take midpoint rule as the better, which is related with the using value y_i calculated by the method (28). Noted that in others cases also have used the value y_i calculated by the method (28).

Table 3. Results Receiving for the Values $h = 0.05$ and $\lambda = \pm 5$.

x	$\lambda = 5$		$\lambda = -5$	
	Method (28)	Trapezoidal rule	Method (28)	Trapezoidal rule
1.1	2.3E-3	5.3E-1	5.1E-8	1.2E-5
1.4	4.4E-2	2.4E 0	4.3E-8	2.9E-6
1.7	3.4E-1	1.1E 1	1.6E-8	6.5E-7
2.0	2.2E 0	4.9E 1	5.2E-9	1.4E-7

Here tabulated the results receiving by the method (28) with the degree $p = 4$ and by the trapezoidal rule with the degree $p = 2$. By the comparison of the results tabulated here, receive that this result corresponding to the theoretical.

Table 4. Results Receiving by the Method (28) and Trapezoidal Rule for $h = 0.1$.

x	$\lambda = 1$		$\lambda = -1$	
	Method (28)	Trapezoidal rule	Method (28)	Trapezoidal rule
1.1	1.5E-7	4.6E-4	2.0E-8	5.9E-5
1.4	8.9E-7	6.2E-4	5.8E-8	4.4E-5
1.7	2.1E-6	8.4E-4	7.5E-8	3.2E-5
2.0	4.1E-6	1.1E-3	7.9E-8	2.4E-5

From the results tabulated here, receive that the error receiving in the using of the method (28), corresponds to the theoretical results. In other words, depends form the values of the solution of the investigated problems the receiving, here errors increases or decreases dependences from the local truncation errors.

Table 5. Results Receiving for the Step Size $h = 0.1$.

x	$\lambda = 5$		$\lambda = -5$	
	Method (28)	Trapezoidal rule	Method (28)	Trapezoidal rule
1.1	2.9E-2	3.5E 0	1.1E-6	1.2 E-4
1.4	6.0E-1	1.6E 1	7.0E-7	2.8 E-5
1.7	4.8E 0	7.4E 1	2.6E-7	6.4E-6
2.0	3.1E 1	3.4E 2	8.2E-8	1.4E-6

By this results receive that the rate of error for the methods decreases correspondingly to the decreasing of the solution.

Table 6. Results receiving by the method (28) for the initial value $y(0)=1$ and $h=0.05$.

x	$\lambda=1$	$\lambda=-1$	$\lambda=5$	$\lambda=-5$
0.1	1.5 E-10	7.0E-11	5.8 E-7	1.9 E-7
0.4	7.1 E-10	4.7E-10	5.7 E-6	7.8 E-7
0.7	1.4E-9	7.2 E-10	2.8E-5	8.7E-7
1.0	2.4E-9	9.1E-10	1.3E-4	8.9E-7

Noted that the results receiving for the value $\lambda=\pm 1$ almost the same, independent from the values of step-size. For this, let us to consider the following tables.

Table 7. Results Receiving by the Method (28) for the Initial Value $y(0)=1$ and $h=0.1$.

x	$\lambda=1$	$\lambda=-1$	$\lambda=5$	$\lambda=-5$
0.1	2.4 E-9	2.2 E-9	9.3E-6	5.6E-6
0.4	1.1 E-8	7.6 E-9	9.1E-5	1.2E-5
0.7	2.3 E-8	1.1E-8	4.6E-4	1.3E-5
1.0	3.9 E-8	1.4E-8	2.1E-3	1.4E-5

In the table (6) and (7) have tabulated the approximately values of the solution of problem (27) for the initial value $y(0)=1$. Therefor the results receiving by the method (28) for the values $\lambda=\pm 5$ are better.

To show the effect of calculation error, here has been solve the following example:

$$y'=\lambda y,\quad y(0)=1. \tag{29}$$

by the method (28) and by trapezoidal rule. It is obvious that this problem follows from the problem (26) in particular case $t=0$. But the better results receiving in solving of the problem (29). This phenomenon explained by the fact that at each step has calculated the term: $t(1-\exp(-\lambda x))+e\lambda\int_0^x \frac{ds}{y(s)}$ in the result of which arises some errors.

Conclusion

For the construction more exact methods, here have suggested to construct methods on the intersection of the multistep methods of advanced and hybrid types. And also have given the advantage of the constructed methods. Prove that proposed here methods are more accurate than the known multistep advanced and hybrid

methods. If compare of advanced and hybrid methods, then receive that the values of degree for hybrid methods more than the values of degree for advanced methods. Established some communication between multistep methods having different properties. Proposed here methods are compares with the Gauss methods. Have shown that the Gauss method can be received from the hybrid methods as the partial case. Consequently, method constructed on the intersection of multistep and hybrid methods are more interesting than other. Noted that the coefficient of some hybrid methods are satisfies the condition which satisfies the coefficients of Gauss methods. As is known the coefficients of Gaussian methods is positive and they are located symmetrically. The coefficients of the hybrid methods also have this. And hybrid methods more exact than the Gauss methods. The class of hybrid methods is wider than the class of Gauss methods. Given the relevance of the study, we can say that soon there will be followers of this topic.

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Analytic Geometry with Air Traffic in the Soft Age

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Abstract: Students usually watch news on TV related to travels and air traffic. It is interesting to talk about these subjects when teaching Analytic Geometry, the students will connect themes such as latitude, longitude and air travels with topics like spherical coordinates, curves on surfaces, vector operations and sphere geometry. Edwards and Penney's book on pages 891 and 892 talk a little about latitude and longitude, and applies these spherical coordinates together with the scalar product of vectors to obtain the great circle distance between New York and London. On page 894 there are some exercises on this subject including a couple ones about a travel between Fairbanks and St Petersburg, show that the shortest journey between north American and northern European cities reach the North Pole, therefore passing over close to Greenland and Iceland, explains the heavy air traffic in that region. With the use of softwares, teachers can invest in this strategy, drawing the trajectories over a sphere and presenting them on earth projections. After solving the Rio de Janeiro to London travel problem, we will discuss the change in two air routes of British and Turkish Airways, caused by the war in Ukraine. We employ Wolfram's Mathematica.

Keywords: Latitude, Longitude, Air Travels, Analytic Geometry with Softwares.

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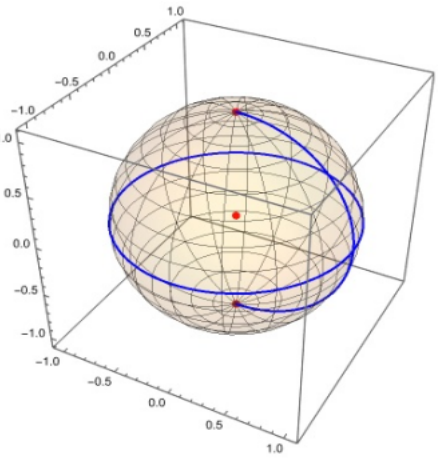
Introduction

For us Earth will be considered as a sphere of unitary radius centered in the origin, $\{0, 0, 0\}$ of the *xyz* system in such a way that the equator is the intersection of the sphere with the plane $z = 0$, Greenwich is the intersection with the half plane $y = 0$, $x \geq 0$, and the North Pole is $\{0, 0, 1\}$. The latitude is λ, between $-\pi/2$ and $\pi/2$, ϕ is the longitude between $-\pi$ and π.

```
γ[{λ_, ϕ_}] = {Cos[λ] Cos[ϕ], Cos[λ] Sin[ϕ], Sin[λ]};
earth = ParametricPlot3D[γ[{λ, ϕ}], {λ, −π/2, π/2},
{ϕ, −π, π}, PlotStyle → Opacity[0.1]];
green = ParametricPlot3D[γ[{λ, 0}], {λ, −π/2, π/2},
PlotStyle → {Thick, Blue}];
eq = ParametricPlot3D[γ[{0, ϕ}], {ϕ, −π, π},
PlotStyle → {Thick, Blue}];
Show[earth, green, eq, Graphics3D[{PointSize[Large],
Red, Point[{{0, 0, 1}, {0, 0, 0}, {0, 0, −1}}]}]]
```



Now we get latitude and longitude for Rio and London.

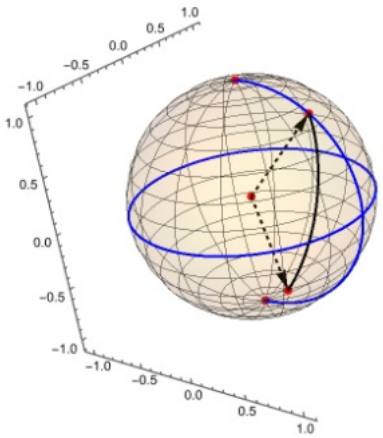
```
{rjdegree, lddegree} = {CityData["RioDeJaneiro", "Coordinates"], CityData["London", "Coordinates"]}
{{−22.91, −43.2}, {51.5, −0.116667}}
{rjrad, ldrad} = Degree{rjdegree, lddegree}
{{−0.399855, −0.753982}, {0.898845, −0.00203622}}
```

Rio's latitude is ≅ -23° South and London's ≅ 51° North, Rio's longitude is ≅ -43° West and London's ≅ 0°.

Rio latitude is $\simeq -23°$ south, London $\simeq 51°$ north, Rio's longitude is $\simeq -43°$ west and London $\simeq 0°$.

$$\text{rjld}[t\_] = \left(\frac{((1-t)\gamma[\text{rjrad}] + t\gamma[\text{ldrad}])}{\text{Norm}[(1-t)\gamma[\text{rjrad}] + t\gamma[\text{ldrad}]]}\right);$$

```
rjldtravel = ParametricPlot3D[rjld[t], {t, 0, 1},
PlotStyle → Black];
vec = Graphics3D[{Black, Thick, Dashed,
Arrow[{{{0, 0, 0}, γ[rjrad]}, {{0, 0, 0}, γ[ldrad]}}]}];
earth3 = Show[earth2, green, eq, rjldtravel,
Graphics3D[{PointSize[Large], Red,
Point[{γ[rjrad], γ[ldrad]}], vec, Boxed → False]
```



The shortest path between the cities is along an arc over a great circle defined by the intersection of Earth with a plane passing through Rio, London, and the center of the Earth. We have drawn this arc by normalizing the straight-line segment between the cities, since we have considered that Earth has a unitary radius.

To calculate the distance between the cities we employ the historical definition of the meter. According to this definition the equator is 40,000 km long and for each 1,000 km over this great circle there are 9 degrees. We can obtain the angle between the unitary vectors linking Earth's center to the cities by using the inner product.

γ[rjrad] • γ[ldrad]
0.114138
rjdlarc = ArcCos[%]
%/Degree
83.4461

(%/90)10000
9271.79
GeoDistance[{rjdegree, lddegree}, UnitSystem → "Metric"]
9253.57

We have obtained $\simeq 83^{\circ}$ between the cities position vectors and a distance that is very close to the one in Mathematica, that employs in its package an oblate ellipsoid model for Earth . . . This means that for air travels the spherical model for Earth and the historical definition of the meter are precisely enough.

In the so called oblate ellipsoidal model for the Earth, the difference between the semi major axis, from the center of the Earth to the equator, and the semi minor axis, from the center to the North Pole, is around 20 km. The average between the two values is approximately the radius in the spherical model, if we assume the historical definition of the meter.

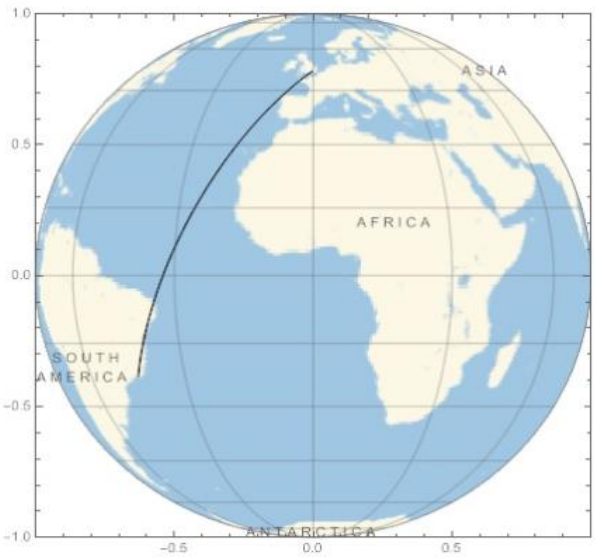
The softs also have many projections of Earth in which you can draw.

GeodesyData["Clarke1866", "Eccentricity"]
0.0822719
N[40000/(2π])]
6366.2

GeodesyData["Clarke1866", "EllipsoidParameters"]
{6378.21, 6356.58}
(1/2)(%[[1]] + %[[2]])
6367.4

The softs also have many options of Earth projections, and we can draw over them.

GeoGraphics[GeoPath[{rjdegree, lddegree}], GeoRange → "World"
GeoProjection → "Orthographic"
GeoGridLines → Automatic, Frame → True]



Two flight Routes Changed Because of the War

The Turkish Airways route between Helsinki and Bangkok can no longer be considered as an arc of a great circle, it had to be changed because of the war in Ukraine. Let's compare the old route with the new one. First, we calculate the length of the route as an arc of a great circle.

```
hskdegree = CityData[“Helsinki”, “Coordinates”]
{60.17, 24.94}
hskrad = Degree%
{1.05016, 0.435285}
bgkdegree = CityData[”Bangkok”, ”Coordinates”]
{13.73, 100.5}
bgkrad = Degree%
{0.239634, 1.75406}
γ[hskrad] • γ[bgkrad]
0.326397
ArcCos[%]/Degree
70.9498
(%/90)10000
7883.31
GeoDistance[{hskdegree, bgkdegree}, UnitSystem → “Metric”]
7893.12
```

Well, it used to be almost 7,900 km long, but now it (Available at: https://pt.flightaware.com/live/flight/THY1795. Acessed on 30 Aug. 2022.) had to be diverted from the conflict region and it has been divided into eight parts, which can be considered as eight circumference arcs (as shown in the map).

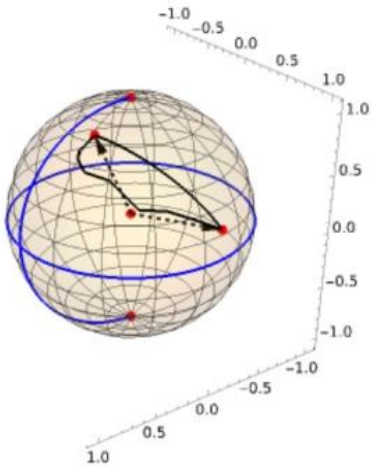
```
{p[0],p[1],p[2],p[3],p[4],p[5],p[6],p[7],p[8]} = {hskdegree, {54.4, 22.8}, {51.5, 20.4},
{47.7, 22.4}, {42.7, 30.1}, {40.6, 45.9}, {28.8, 60.9}, {27.8, 73.3}, bgkdegree};

  GeoGraphics[Table[GeoPath[{p[j], p[Mod[j + 1, 9]]}], {j, 0, 8}],
  GeoProjection → “Mercator”, GeoGridLines → Automatic, Frame → True]
  Normal[GeoDistanceList[Table[p[j], {j, 0, 8}], UnitSystem → “Metric”]]
  {655.316, 360.747, 446.64, 829.726, 1334.63, 1892, 74, 1220.77, 3220.55}
  Sum[%[[j]], {j, 1, 8}]
  9952.12
```

Consequently, the new flight route from Helsinki to Bangkok is almost 10,000 km long… much longer.

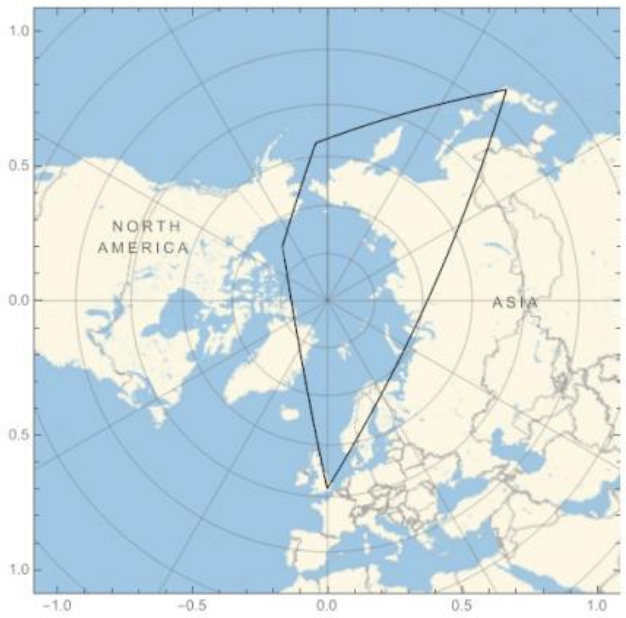
```
{q[0],q[1],q[2],q[3],q[4],q[5],q[6],q[7],q[8]} = Degree{p[0],p[1],p[2],p[3],p[4],p[5],p[6],p[7],p[8]};
Table[((1 − t)γ[q[j]] + tγ[q[Mod[j + 1, 9]]])/(Norm[(1 − t)γ[q[j]] + tγ[q[Mod[j + 1, 9]]]]), {j, 0, 8}];
hskbkgtravel = ParametricPlot3D[%, {t, 0, 1}, PlotStyle → Black];
```

```
vec2 = Graphics3D[{Black, Thick,
Dashed, Arrow[{{{0, 0, 0}, γ[hskrad]},
{{0, 0, 0}, γ[bgkrad]}}]}];
Show[earth2, green, eq, hskbkgtravel,
Graphics3D[{PointSize[Large], Red,
Point[{γ[hskrad], γ[bgkrad]}]}],
vec2, Boxed → False]
```



The same has happened to the route of British Airways from London to Tokyo that cannot follow only one arc of a great circle either. (Available at: https://edition.cnn.com/travel/article/north-pole-air-route/index.html. Acessed on 30 Aug. 2022.)

```
tkdegree = CityData["Tokio", "Coordinates"]
{35.67, 139.77}
tkrad = Degree %
{0.622559, 2.43945}
{pt[0],pt[1],pt[2],pt[3],pt[4],pt[5]} = {lddegree,77.3, -134.3,75.1, -140.2,57.3, -175.7,44.4, 150.2, tkdegree};
GeoGraphics[Table[GeoPath[{pt[j], pt[Mod[j + 1, 6]]}], {j, 0, 5}], GeoProjection → "Stereographic",
GeoCenter → {90, 0}, GeoGridLines → Automatic, Frame → True]
```



Let's calculate the length of the old route as an arc of a great circle.

```
γ[ldrad] • γ[tkrad]
0.069588
ArcCos[%]/Degree
86.0097
```

```
(%/90)10000
9556.63
GeoDistance[{lddegree, tkdegree},
UnitSystem → "Metric"]
9857.44
```

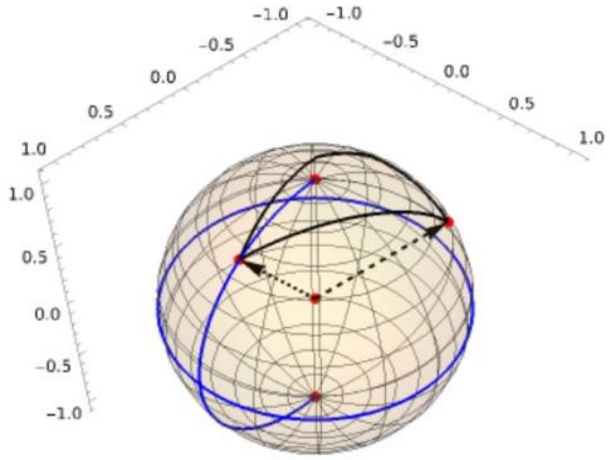
The angle between the position vector of the two cities is ≃ 86◦, the distance between them along the great circle arc is ≃ 9,900 km. Now let's see length of the new route

```
Normal[GeoDistanceList[Table[pt[j], {j, 0, 5}], UnitSystem → "Metric"]]
{5364.35, 291.269, 2468.95, 2754.82, 1313.92}
Sum[%[[j]], {j, 1, 5}]
12193.2
```

. . . It is now over 12,000 km, meaning that the new route is much longer than the old one.

```
{qt[0],qt[1],qt[2],qt[3],qt[4],qt[5]} = Degree{pt[0],pt[1],pt[2],pt[3],pt[4],pt[5]};
Table[((1 − t)γ[qt[j]] + tγ[qt[Mod[j + 1, 6]]])/(Norm[(1 − t)γ[qt[j]] + tγ[qt[Mod[j + 1, 6]]]]), {j, 0, 5}];

ldtktravel = ParametricPlot3D[%, {t, 0, 1}, PlotStyle → Black];
vec3 = Graphics3D[{Black, Thick, Dashed, Arrow[{{{0, 0, 0},
γ[ldrad]}, {{0, 0, 0}, γ[tkrad]}}]}];
Show[earth2, green, eq, ldtktravel, Graphics3D[{PointSize[Large],
Red, Point[{γ[ldrad], γ[tkrad]}]}], vec3, Boxed → False]
```



Recommendations

We recommend this type of work to engineering students, who will see some nice applications of Analytic Geometry with software to understand everyday themes like air travels and air traffic.

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Examination of the Relationship between Epistemological Beliefs of Primary School Teachers and Social Studies Teachers, and Technological Pedagogical and Content Knowledge

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Abstract: Changing developments in the 21st century have also affected technology and the epistemological beliefs of teachers. For this purpose, the epistemological beliefs and TPACK levels of classroom teachers and social studies teachers, gender, age, professional seniority, educational status, branch variables, and the relationship between epistemological belief and TPACK were examined. The study group of the research consists of classroom teachers working in public primary schools and social studies teachers working in public secondary schools in the provinces and districts of Istanbul, Antalya, Isparta. The selection of the study was made with the appropriate sampling method, which is one of the non-accidental sampling methods. 178 classroom teachers and 48 social studies teachers participated in the research. Unrelated samples t test, Mann Whitney U test, Kruskall Wallis test and Pearson Correlation Analysis were used in data analysis. According to the results obtained from the research, both classroom and social studies teachers have a high level of belief in the effort sub-dimension. It was observed that both primary school teachers and social studies teachers had high TPACK levels. Considering the epistemological belief scale, no significant difference was observed according to the age, education level and professional seniority of the classroom teachers. There was no significant difference in social studies teachers according to the gender variable. According to the results obtained from the TPACK scale and its sub-dimensions, a significant difference was observed in terms of gender and professional seniority of classroom and social studies teachers. A low level of positive correlation was found between the effort scores of the classroom teachers, TB, AB, TPB, TAB and TPACK total scores.

Keywords: Epistemological Belief, Social Studies, Technology Pedagogy Content Knowledge

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Introduction

The 21st century, with the innovations in the education world, there have been many changes in the field of education. Constructivist understanding comes at the beginning of the changes in the field of education. With the constructivist understanding, the teacher plays a guiding role in learning and enables the students to access the information themselves. With this understanding, the development of the epistemological belief system has also gained importance by aiming to develop a positive attitude in the behavior of the individual (Demir & Akınoğlu, 2010). Deryakulu (2014) considers epistemological belief as a form of realization of knowledge and learning and reveals that there is an individual belief system about knowledge; according to Olafson, Schraw & Vander Veldt (2010), it expresses beliefs about knowledge.

According to Usta (2019), there are a limited number of studies on the research of epistemological beliefs of teachers. This is most likely related to the work the teachers (Akman et al., 2022a; Akman et al., 2022b; Aksan & Sözer, 2007; Bakir & Adak, 2014; Biçer, B., Er, H. & Özel, 2013; Demir, 2012; Demirbilek et al., 2021; Er, 2013; Eren, 2010; Gürol, Altunbas & Karaaslan, 2010; IRA & Switches, 2017; Goalkeeper, 2012; Akbas and Kanadli, 2015; Karatas, 2011; Ocak & Erbasan, 2017; Şenler & İrven, 2016; Terzi ,2005; Turkan, Aydin, & Üner, 2016). Accordingly, class teachers and social studies teachers ' technological pedagogical content knowledge related to epistemological beliefs and teaching methods and practices in social studies contributes to this research report, primary teachers, while the teachers to rate yourself in terms of professional development will consist of. In this regard, the work done is important in terms of its originality.

In the light of the above literature, the purpose of this study is; is there a significant difference in the epistemological beliefs and technological pedagogical domain knowledge levels of classroom teachers and social studies teachers according to gender, age, seniority, educational status? Is there a relationship between the epistemological Decisiveness and technological pedagogical domain knowledge level of classroom teachers and social studies teachers? Answers to their questions have been sought.

For this purpose, answers to the following subproblems were sought:

1. At what level are the epistemological beliefs of classroom and Social studies teachers?
2. What is the level of technological pedagogical content knowledge of classroom and Social studies teachers?
3. Do the epistemological beliefs of classroom and social studies teachers differ according to their branch, gender, age, educational level, and professional seniority?
4. Does the technological pedagogical content knowledge of Classroom and Social Studies teachers differ according to their branch, gender, age, educational level, professional seniority?
5. Is there a significant relationship between epistemological Decisiveness and technological pedagogical domain knowledge level of Classroom and Social Studies teachers?

Method

Research Model

The research was conducted as quantitative research. The research was carried out with descriptive and relational screening models from the screening models. The screening model is a model in which data are collected through surveys and interviews and reflects the research situation as it is (Büyüköztürk et al., 2020; Fraankel et al., 2012; Özmen and Karamustafaoğlu, 2019). Relational screening is a research in which the change of two or more variables is revealed (Karasar, 2020). The research selection was made by appropriate sampling method from non-selective sampling methods. Appropriate sampling is "a method of selecting the sample from accessible, easily applicable units due to the limitations that exist in terms of time, money and labor" (Büyüköztürk et al., 2020, p.103). In this research, the relationship between epistemological belief and technological pedagogical content knowledge levels of classroom and social studies teachers has been Deciphered according to the relational screening model.

Participants

The participants of the research consisted of a total of 226 volunteer classroom and social studies teachers working under the Ministry of National Education in the spring semester of 2021-2022.

Collection of Data

In order to examine the relationships between epistemological beliefs and TPACK of classroom teachers and social studies teachers, Aydın et al. Deciphered the relationship between epistemological beliefs and TPACK. the "epistemological belief scale" developed by (2017) and the "technology, pedagogy and domain knowledge scale" developed by Akman (2014) were used. Due to the fact that the research is easily accessible, it has been prepared with Google form and it has been requested to be done in the form of online approval via the specified link. After obtaining the necessary permits, interviews were conducted with the provincial and district directorates of national education for sharing links.

Data Collection Tools

The data were collected in three sections. The personal information form is the epistemological belief scale and the technological pedagogical content knowledge scale. In the personal information form, gender, age, branch, education status and professional seniority information are included from the demographic characteristics of the teachers. The 35-item epistemological beliefs scale, developed by Schommer (1990) and adapted to Turkish by Deryakulu and Büyüköztürk (2002) in the collection of research data, was developed by Aydın et al. (2017) conducted a validity and reliability study of the Turkish Form and used the epistemological beliefs scale adapted to 29 items. Aydın et al. (2017) of the scale created by 10. Instead of the expression "good" in the article,

"hardworking"; 26. in the article, the expression "social studies" course was used instead of "science" course. 15.the item is removed from the scale.

In the research, the technological, pedagogical and domain knowledge scale developed by Akman (2014) will be applied for the TPACK scale. The scale consists of 55 items. The scale was prepared in the five-point likert type. The scale has options in the form of 1-2-3-4-5 and consists of 5 items.

Validity and Reliability Study

According to the reliability analysis results obtained in our research (Cronbach Alpha), the first factor is 0.79, the second factor is 0.83, and the third factor is 0.75 on the epistemological belief scale. The first factor was found to be 0.89, the second factor, 0.89, the third factor, 0.96, the fourth factor, 0.96, the fifth factor, 0.96, the sixth factor, 0.96, the seventh factor, 0.80 on the TPACK scale. According to the data obtained from the sub-dimensions of the scales, it was understood that the measurement tool was reliable.

Analysis of the Data

SPSS program was used while analyzing the research data. According to the data obtained from the study, it was examined whether the point distributions were normal or not, skewness and kurtosis values were examined. In cases where the independent variables show a normal distribution, the t-test was used for unrelated samples if the number of categories is two, ANOVA analysis was used if the number of categories is more than two and the variances are homogeneous. If the number of categories is not normal, the Mann Whitney U test was used for unrelated samples if the number of categories is two, and the Kruskall Wallis test was used if the number of categories is more than two. In order to perform relational screening, Spearman Brown Correlation coefficient was calculated in cases where the data showed normal distribution and Pearson Correlation coefficient in cases where it did not show.

Results

This section consists of showing and interpreting statistical values made according to the data obtained from the problems and subproblems of the research.

The Findings Obtained According to the Branch Variable

Within the scope of the research, it was examined whether the scores obtained by teachers from all epistemological belief and technology, pedagogy, field knowledge scales and their sub-dimensions differ according to the branch variable. The results of the Mann Whitney U test and the t-test are given in table 1 for the unrelated samples for the study, and the results of the Mann Whitney U test are given in table 2.

Table 1. Comparison of unrelated samples t-test according to the branch variable of teachers

Scale/Sub-Dimension	Group	N	$\bar{X}$	sd	T	P
Only one truth	**Class Teacher**	178	16.76	224	3.96	0.00*
	Social Studies Teacher	48	13.67			
Technology knowledge	**Class Teacher**	178	25.89	224	-0.19	0.85
	Social Studies Teacher	48	26.04			
Pedagogical knowledge	**Class Teacher**	178	23.11	224	-1.10	0.28
	Social Studies Teacher	48	23.79			
Domain information	**Class Teacher**	178	37.19	224	-5.46	0.00*
	Social Studies Teacher	48	43.35			
Knowledge of the field and pedagogy	**Class Teacher**	178	25.90	224	-3.32	0.00*
	Social Studies Teacher	48	28.81			
Knowledge of technology and pedagogy	**Class Teacher**	178	34.99	224	-1.16	0.25
	Social Studies Teacher	48	36.19			
Field and technology knowledge	**Class Teacher**	178	37.53	224	-1.78	0.10
	Social Studies Teacher	48	39.71			
Technology, pedagogy field knowledge total	**Class Teacher**	178	207.02	224	-2.89	0.01*
	Social Studies Teacher	48	221.60			

Table 1 independent samples t-test results were examined, only one of the teachers of classroom teachers in favor of the correct score variable according to the major field of knowledge, and knowledge of the field of pedagogy with technology, pedagogy knowledge scores showed statistically significant differences in favor of the field of social studies teachers were identified ($p<0.05$).

Table 2. Comparison of Mann Whitney U test according to the branch variable of teachers.

Ölçek/ Alt Boyut	Grup	N	$\bar{X}$	Total	U	p
Effort	**Class Teacher**	178	109.82	19548.50	3617.50	0.10
	Social Studies Teacher	48	127.14	6102.50		
Talent	**Class Teacher**	178	118.96	21174.00	3301.00	0.02*
	Social Studies Teacher	48	93.27	4477.00		
Epistemological belief	**Class Teacher**	178	117.41	20898.50	3576.50	0.08
	Social Studies Teacher	48	99.01	4752.50		
Technology, pedagogy and field knowledge	**Class Teacher**	178	109.93	19567.00	3636.00	0.11
	Social Studies Teacher	48	126.75	6084.00		

When the Mann Whitney U test results in Table 2 were analyzed, it was found that the ability scores of teachers showed statistically significant differences in favor of classroom teachers according to the branch variable ($p<0.05$).

Discussion and Conclusion

According to the results obtained according to the branch variable; it was found that the teachers' single correct and ability scores showed a significant difference in favor of the classroom teachers. In other words, the single correct and ability scores of classroom teachers are higher than those of social studies teachers. The total effort and epistemological scores of the teachers do not show significant differences according to the branch variable. In support of the research result, a study conducted by Içen (2012) found that social studies teachers have a belief in the sub-dimension of "Learning does not depend on effort".

In this regard, the traditional approach is observed in social studies teachers. In the study conducted by Usta (2019), which determined the epistemological beliefs of classroom teachers, classroom teachers are closer to traditional beliefs. In this respect, it was seen that classroom teachers and social studies teachers showed similar results. In the research conducted by Kösemen (2012), there was no significant difference in the epistemological beliefs of classroom teachers and social studies teachers according to the branch variable. In a study conducted by Deryakulu and Buyukozturk (2005), students studying classroom and social studies teaching have more mature epistemological beliefs in favor of students studying computer technology.

It has been found that AB, PAB, TPACK scores show significant differences in favor of social studies teachers. The total scores of AB, PAB, TPACK of social studies teachers are higher than those of classroom teachers. It was found that teachers did not show significant differences in TB, PB, TPB, TAB sizes. In other words, the TB, PB, TPB, TAB scores of classroom and social studies teachers are similar. When we look at the literature, there are studies that have similar results with our research (Akman & Alagoz, 2019; Akman, Karaaslan, & Bayram, 2022; Akturk & Saka Ozturk, 2019; Barksdale, Upadhyay, & Vernon, 2021; Joldanova et al., 2022; Kaleli, 2021; Karademir, 2015; Kara, 2021; Kazu & Erten, 2014; Koyuncuoglu, 2021; Kukul, 2022; Kula, 2015; Mutlu, Polat, & Alan, 2019; Putri et al., 2022). The reason for this difference is; in the research conducted by Aksin (2014), it is stated that social studies teachers have confidence in themselves towards the EU.

According to the research results, the fact that the AB, PAB, TPACK levels are in favor of social studies teachers may be due to the fact that social studies teachers see themselves at a more adequate level about the EU. Significant differences in TPACK sub-dimensions may negatively affect the lesson by both classroom teachers and social studies teachers when considered from the point of view of the social studies lesson. For an effective training, all sub-dimensions should contain similar results.

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Polymer-based Nano-material – Gum Acacia as an Admixture for Concrete

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Abstract: Synthetic and bio-admixtures have become necessary components of concrete and are used to produce particular engineering properties. The use of chemical admixtures is still quite low due to their availability. However, this will soon change due to accelerated research in the use of agro-waste materials and other easily available polymers on the continent. The use of bio-admixtures has grown recently due to advances in technology and the need to use sustainable biodegradable construction materials. New products can now be applied in concrete technology due to the use of Nanotechnology which offers such possibilities. One example of such implementation is the development of Acacia Gum as an admixture in concrete. Gum acacia oozes from the bark of the acacia tree which is found in almost all countries in Africa. This bio-based polymer has been shown to extend the setting time, increase slump, and acts as a water-reducing admixture in concrete. This shows that High-Performance Concrete with complex rheological properties can be achieved by using polymer-based bio-admixtures. To further understand this admixture, zeta potential in the presence and without calcium ions in the dispersion medium were studied at different hours and dosages of gum namely: 0%, 0.3%, 0.5%, 0.8%, and 1%. The effect of the flowability of cement paste on the additional time was studied at 0.8% dosage using a Texture Analyser. Measurements were taken at an early age of 1, 3, 4, and 5 hours after mixing. Results showed negative zeta potentials for all dosages which changed with time and that flowability of paste was greatly influenced by the time of addition of the admixture.

Keywords: Acacia Gum 1, Texture analysis 2, Dosage 3, Water-cement ratio 4, Addition-time 5

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Introduction

It is common practice to use chemical admixtures in concrete to reduce water demand and or enhance concrete properties. Most chemical admixtures used in Africa are imported from industrialized countries and may contribute to environmental pollution in several ways. Chemical admixtures may lead to pollution during

production, storage, and handling. These admixtures are transported for long distances and are not renewable (Bessaies-Bey et al., 2016). They pose not only a health effect to the workers (some polymers may include sulfonated naphthalene formaldehyde (SNF) condensate and sulfonated melamine formaldehyde (SMF) condensate which may release toxic chemicals into the environment (Kavas et al., 2005; Kim et al., 2000; Ouyang et al., 2009). In this sense, the civil construction industry in Africa also has significant importance in studying chemical admixtures that are sustainable. Research in this area is still limited but a few researchers mentioned here indicate the potential of this industry (Rizwan, 2019, Mouanda, 2022; Brzyski, 2021). It is also an opportunity for Africa to innovate green concrete, with materials that are locally sourced to reduce costs. The use of Bio-admixtures undoubtedly represents an innovative and cutting-edge issue for the sustainable civil engineering industry (Schmidt et al., 2019).

The use of chemical admixtures in concrete especially in Africa is critical due to the hot temperatures experienced in most parts. Lack of use of chemical admixtures may result in problems like hardening of concrete, workability, strength, and durability issues. The effectiveness of chemical admixtures depends on the water content, type of cement, mixing time, and temperature. The current admixtures used can affect the same mix composition differently depending on the composition of cement and source of aggregates. The fact that the real composition of the chemical admixtures is not known due to the secrete of the industry does not help the construction industry to study their effect on concrete effectively. Hence there is a great need to study new materials which are known, and the real composition of the admixtures is well-defined and known. This paper further investigates the use of Acacia Gum (AG) whose composition is well known as an admixture in cement mortar (Mbugua et al., 2016). To study these new materials, new methods need to be exploited to study their effectiveness. Hence this study tried a method used in the food industry ie Texture analysis to study the effect of the admixture while added at different times using different water-cement ratios. Zeta potential measurements of AG dissolved in water were also studied.

Table 1. Test Schedule for Texture Analysis

Variables		dosage	AG (g)	Age of testing
	0.3	0.8	1.16	1,4,5hrs
w/c	0.4	0.8	0.992	1,4,5hrs
	0.5	0.8	0.572	1,4,5hrs

Method

Zeta Potential

Malvern Zetasizer Nano zs was used to measure electrophoretic mobility. AG weighing 0.04g was mixed with 4g of deionized water or saturated Calcium Hydroxide $Ca(OH)_2$. The sample was shaken well until AG dissolved.

Texture Analysis

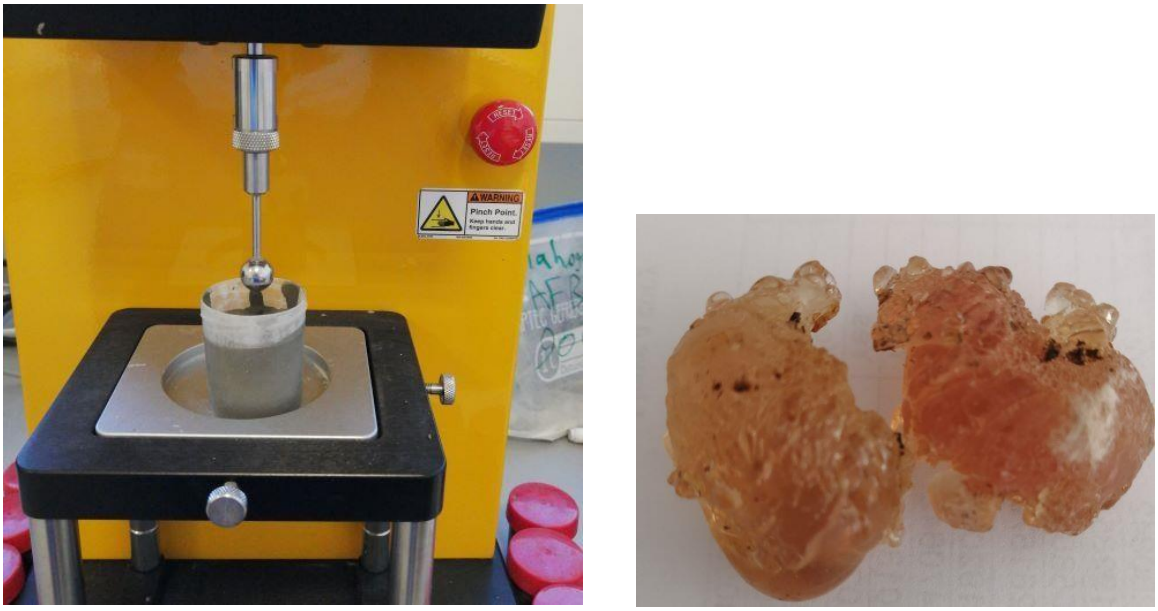

Figure 1. a) Cement Mortar Sample on Table TA-BT-KIT about to be tested. b) AG Tears

Texture analysis was performed using a CT3 Texture Analyzer (Brookfield Engineering Labs, Middleboro, USA). The test was performed by using a cylindrical probe (25.4 mm diameter) at 1 mm/s rate to 50% deformation Compression test type and Table fixture TA-BT-KIT (Figure 1a) with a specified distance of 32 mm upon trigger load as the target was used. The test speed and post-test speed were set at 1 mm/s. The force (g) required to compress the material was measured and recorded using ProCT software.

Ordinary Portland cement (OPC) cement was used for all the tests. Deionised water was used to prepare all the samples and conducted at 22 ± 2℃. AG tears (Figure 1b) were ground to a fine powder after removing debris.

Samples were prepared using different w/c ratios (0.3, 0.4 and 0.5). Table 1 shows schedule of texture analysis tests. AG was added at three regimes; a) cement was added to water and after mixing for two minutes, powdered AG was added and the mixture was further mixed for another two minutes (OPC+H2O+AG): b) AG was added to 20% of batch water, mixed for two minutes, next cement was added and sample mixed for another two minutes and finally the remaining 80% of batch water was added and mixing continued for another two minutes (20%H20+AG+OPC+80%H20). c) Powdered AG and OPC were mixed in dry state and the mixer was added to batch water and mixed for four minutes (AG+OPC+H20. The las sample acted as control where cement was mixed with water (OPC+H2O). The cement paste which was prepared in a large container were then transferred into smaller plastic containers (with a diameter of 30mm and a height of 44mm). The dosage of AG was kept constant for all samples at 0.08% weight cement apart from the control which did not contain AG.

Results

Zeta Potential

Higher negative Zeta potential results shown were achieved as the age of the sample increased. The presence of calcium ions and the higher pH did not significantly change the zeta potential at any time. Unlike other + polymers such as polycarboxylate ethers the zeta potentials do not become less negative in the presence of calcium ions. This can indicate that the complex polymer shields the negatively charged functional groups from interactions with ions in the solution. It can be observed that with time the zeta potential in all cases becomes more negative, which could indicate that the deprotonation of carboxylate continues with time.

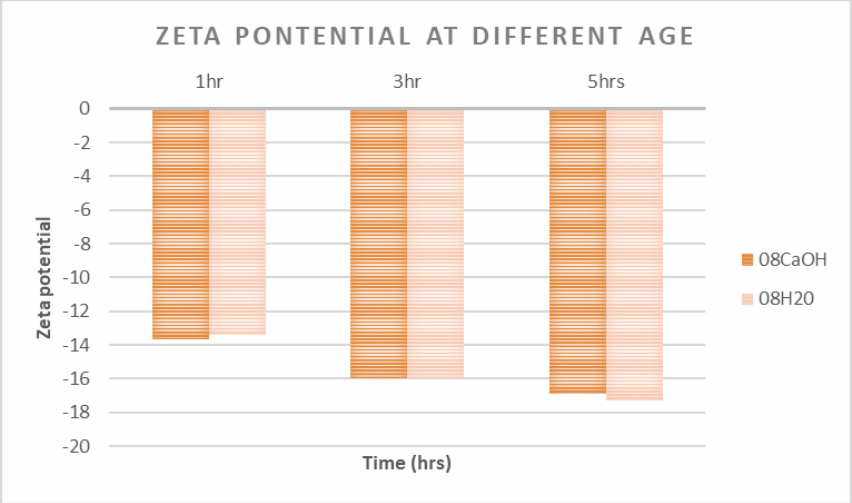

Figure 2. Zeta Potential of AG dissolved in Water and Lime Water

Texture Analysis

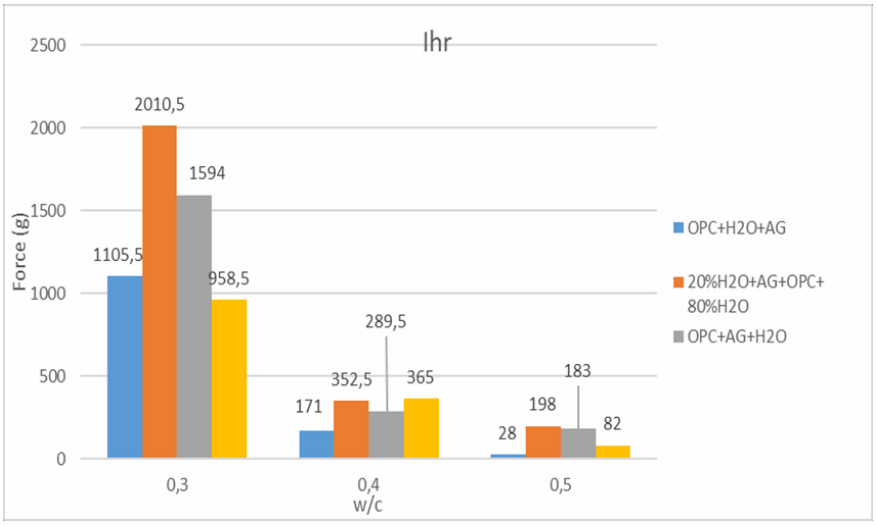

Figure 3. Force of Indent versus w/c Ratio at 1 Hour of Age

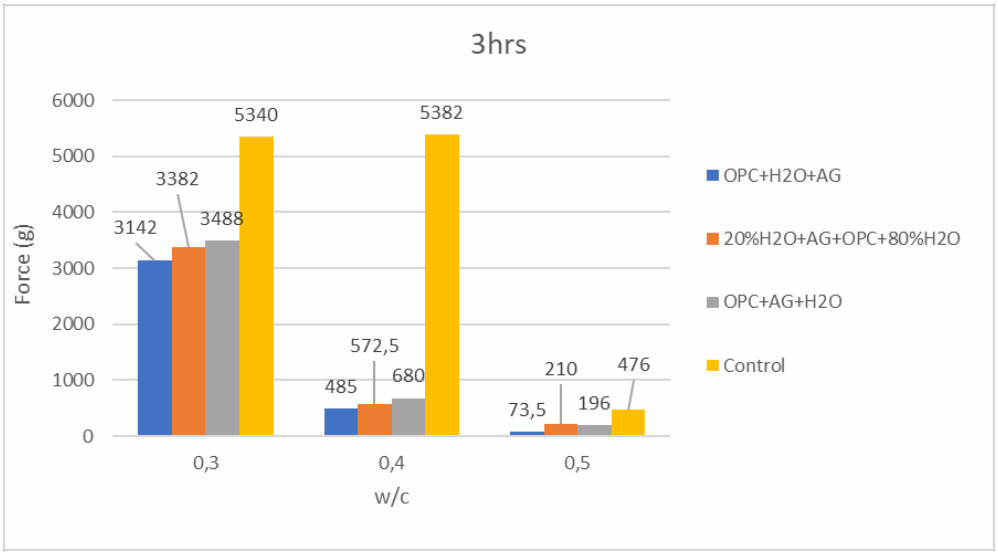

Figure 4. Force of Indent versus w/c at 3hrs of Age

Figure 3 shows maximum force recorded during sample testing after I hr. Highest force recorded was when 20% of batching water was mixed with AG, followed by addition of cement and finally addition of the remaining water. It was noted that force was dependent on the water-cement ratio, and it decreased not only with the increase in the w/c ratio but also increased as the age of the sample increased. At a 0.3w/c ratio, the amount of water in the mix was not enough to react with cement and release the plasticizing effect of AG.

Figures 5 and Figure 6 reveal the effect of AG with age. Enhanced effect of AG at high w/c (0.4 and 0.5) , and at late age (4hrs and 5hrs) was observed and required much less force to indent compared to samples without AG (Fig 5 and Figure 6) . The control sample developed strength much faster as the age increased and hence required more force to indent but decreased as the w/c ratio increased for all ages except at 5hrs (Fig 6).

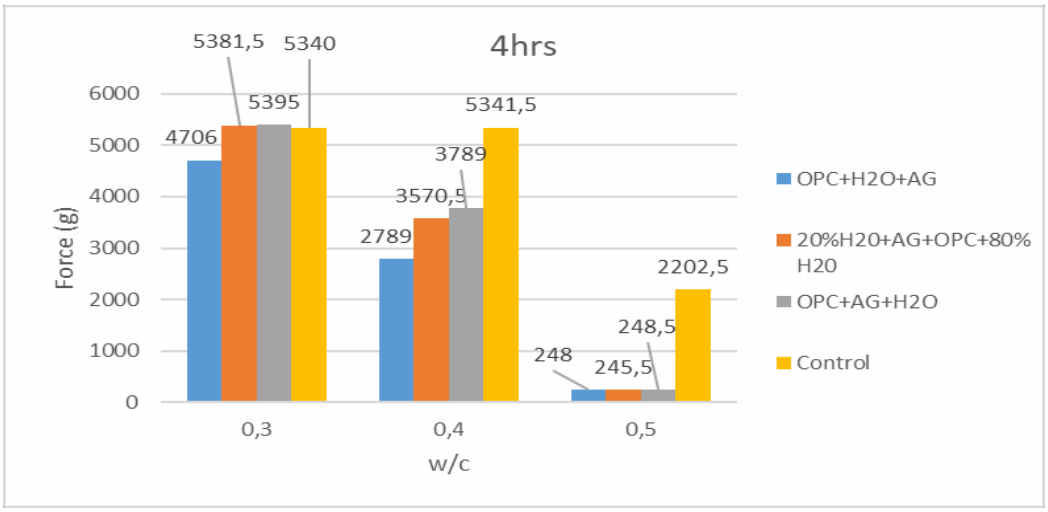

Figure 5. Force of Indent versus w/c at 4 hrs of Age

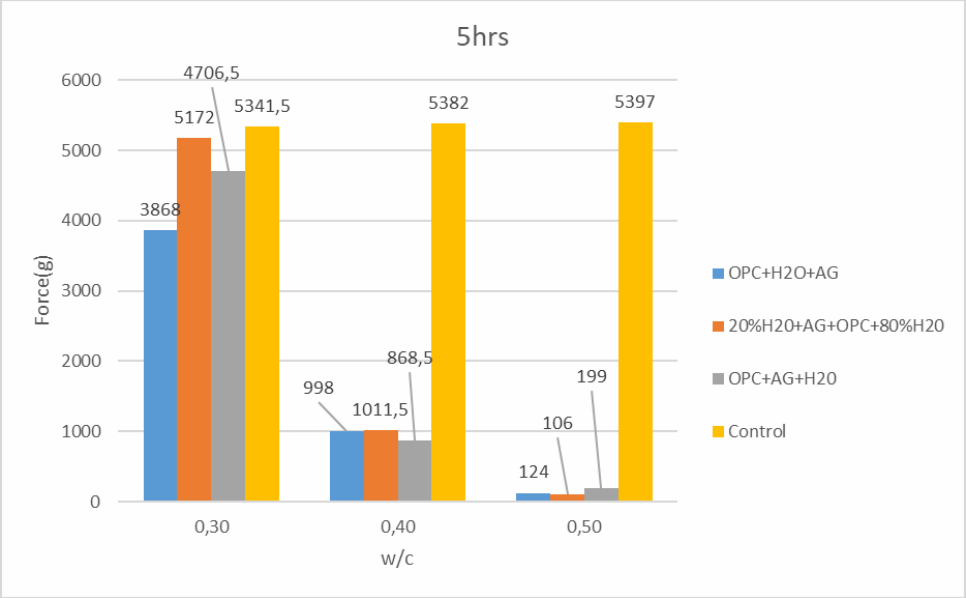

Figure 6. Force of Indent versus w/c at 5 hrs of Age

Discussion

The amount of force required to compress the samples with AG at a 0.4w/c ratio is much higher than at the same w/c but at 5 hrs of age. The probable explanation is that AG took time to dissolve in water. It also suggests that addition of AG induced the dispersive effect in the OPC whereby cement flocculated structures were dismantled and consequently releasing more water that was entrapped within the particles (Zhang et al., 2012). At higher w/c ratio of 0.5, minimum force was required due to the plasticizing property of AG. Increased w/c ratio played a significant part in the rheology of the samples. More water content available in the samples dissolved more AG. It is clear the addition time of AG greatly influenced the retardation effect not only due to w/c ratio but also due to the age of samples. The time of addition of AG to a mixture of cement and water performed better at low w/c ratio at all ages. At low w/c ratio, OPC did not compete for water present with AG but late addition of AG assisted in releasing the entrapped water. Delaying addition of AG improved rheological properties of the samples especially at early age of 1hr, 3hrs and 4hrs. This agrees with other researchers {Aiad, 2003}, {von Daake, 2017}.

Conclusion

Zeta potential of AG dissolved in water and CAOH became more negative- indicating that the polymers adsorb on particle surfaces. The presence of calcium ions and the higher pH did not significantly change the zeta potential at any time. Gain of strength for all samples was influenced by w/c ratio but also the addition time addition of AG though not significantly. At low w/c ratio addition of AG to OPC and water mixer was more effective at all ages. However, increase in w/c ratio and addition time of AG did not have much influence of strength formation for samples with AG. Gain in strength was mostly influenced by the presence of AG as opposed to time of addition. Delay in addition time of AG had slight improvement on rheology at early age. At

early age and high w/c ratio the formation of gel was almost negligible for samples with AG while the control gained strength as expected.

Delay in additional time of AG had slight improvement on rheology at an early age. At an early age and high w/c ratio, the formation of gel was almost negligible for samples with AG while the control gained strength as expected. The texture analysis measurement of cement pastes flow can be used to quantitatively show exactly the effect of time of addition of AG by revealing when the pastes start to stiffen. This method if fully developed can give more information on the microstructure formation of pastes in a shorter time compared to other penetration tests such as Vicat.

Recommendations

This method of measurement of strength development revealed the effect of w/c ratio on the addition time of AG. Although not a conventional method of measuring strength development further studies can be carried out to compare these results with e.g. setting time and compressive strength tests so as to improve its reliability.

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