Yaşar, M. D., & Sadi Yılmaz, S. (2020). Analysis, evaluation, and comparison of the 2007, 2013 and 2018 chemistry curriculum learning outcomes based on the revised Bloom's taxonomy. *Bartın University Journal of Faculty of Education*, 9(2), 264-278.

Bartın University Journal of Faculty of Education, 9(2), 264-278

buefad.bartin.edu.tr

Analysis, Evaluation, and Comparison of the 2007, 2013 and 2018 Chemistry Curriculum Learning Outcomes Based on the Revised Bloom's Taxonomy

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Article Info

DOI: 10.14686/buefad.590764

Article History:
Received: 11.07.2019
Accepted: 05.05.2020
Published: 05.06.2020

Keywords:
High School Chemistry Curriculum,
Learning Outcomes,
Revised Bloom Taxonomy.

Article Type:
Research article

Abstract

The taxonomy approach in education provides teachers with an insight into learning outcomes in curricula and assessment of students. This study examines the chemistry curricula published by the Ministry of National Education of Turkey in the years 2007, 2013, and 2018 based on the knowledge and cognitive process dimensions of the Revised Bloom's Taxonomy (RBT). In the study, document analysis which is one of the qualitative research designs was used. Reliability analysis was made through examination of two researchers' agreements and disagreements. The reliability coefficient of the study was calculated to be 90.57%. Examining the chemistry curricula based on year and grade, the study found that learning outcomes associated with conceptual knowledge were a lot in the knowledge dimension while learning outcomes associated with understanding were many in the cognitive process dimension. The study is significant as it shows how learning outcomes changed in chemistry curricula in terms of RBT from 2007 to 2018. This study may be supported by research that determines students' RBT levels at the end of assessment in chemistry courses or the RBT levels of questions asked to students.

2007, 2013 ve 2018 Yılları Kimya Dersi Öğretim Programları Kazanımlarının Yenilenmiş Bloom Taksonomisi'ne Göre Analiz Edilmesi, Değerlendirilmesi ve Karşılaştırılması

Makale Bilgisi

DOI: 10.14686/buefad.590764

Makale Geçmişi:
Geliş: 11.07.2019
Kabul: 05.05.2020
Yayın: 05.06.2020

Anahtar Kelimeler:
Lise Kimya öğretim programı,
Kazanımlar,
Yenilenmiş Bloom Taksonomisi.

Makale Türü:
Araştırma makalesi

Öz

Eğitimde taksonomi yaklaşımı öğretmenlere, öğretim programlarındaki kazanımlar ve öğrencilerin değerlendirilmeleri hakkında fikir vermektedir. Bu çalışmada Milli Eğitim Bakanlığı tarafından 2007, 2013 ve 2018 yılları arasında yayınlanan Kimya Öğretim Programları, Yenilenmiş Bloom Taksonomisi'ndeki (YBT) bilgi ve bilişsel süreç boyutlarına göre incelenmiştir. Araştırmada, nitel araştırma desenlerinden biri olan doküman analizi kullanılmıştır. Çalışmada iki araştırmacının görüş birliği ve görüş ayrılıkları incelenerek güvenirlik analizi yapılmıştır. Çalışmanın güvenirlik katsayısı %.90.57 olarak hesaplanmıştır. Çalışma sonunda kimya dersi öğretim programı yıllara ve sınıf düzeylerine göre incelendiğinde bilgi boyutunda kavramsal bilgi basamağındaki kazanımların fazla olduğu, bilişsel süreç boyutunda ise anlama düzeyindeki kazanımların fazla olduğu tespit edilmiştir. Çalışma kimya öğretim programındaki kazanımların YBT'ye göre 2007 yılından 2018 yılına kadar nasıl bir değişim gösterdiğini ortaya koyması açısından önem arz etmektedir. Mevcut çalışma, öğrencilerin kimya derslerinde yapılan ölçme değerlendirme sonucunda YBT'ye göre hangi basamakta olduklarının tespit edilmesiyle veya öğrencilere sorulan soruların YBT'ye göre hangi basamakta olduğunun tespit edilmesiyle desteklenebilir.

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Introduction

"*Is mathematics, for example, a discrete body of knowledge to be memorized or an organized, coherent, conceptual system to be understood? Does reading consist of remembering a set of sound-symbol relationships or gaining meaning from the words on a printed page?*" (Anderson, et al., 2010).

Objectives guide individuals' efforts in life. They show what an individual wants to achieve. Today, objectives are addressed as content or curriculum standards. These standards may be illuminating and beneficial on one hand but confusing on the other hand (Anderson et al., 2010).

Qualifications to be gained by people through education have a long list (Doğanay & Sarı, 2008, p.44). A curriculum is a process involving methods, techniques, and assessment activities for providing relevant contents through activities inside and outside the classroom conducted for attaining the objectives of national education and of educational institutions in any educational stage. It is a guide for courses in different grades in terms of subjects to be covered, goal to be achieved, duration, method, and techniques (Büyükkaragöz & Çivi, 1999, p.190). Teachers may encounter problems in terms of course content and time limitation problems unless serious and difficult decisions are made on what to teach and at which level to teach (Anderson et al., 2010). Educationists have proposed certain taxonomies by considering the common aspects of the above-mentioned qualifications. Taxonomy in education involves organizing or arranging behaviors that are intended for individuals to attain from simple to complex, from easy to difficult, and from concrete to abstract in such a way that they are prerequisites for one another (Sönmez, 2010).

The taxonomy approach gives teachers an idea about what they are trying to achieve as well as the understandability and observability of the learning outcomes in curricula and can be used for the analysis of student work. It guides teachers especially when they are preparing questions for assessing students. It helps teachers make out objectives (Anderson et al., 2001; Zorluoğlu, Kızılaslan & Sözbilir, 2016; Cangüven, Öz, Binzet & Avcı, 2017; Beyreli & Sönmez, 2017). It covers categories and groups about a single being, event, or situation. For example, there are birds, reptiles, mammals, etc. in the living beings group. When a species is called reptile, we understand that it bears the characteristics of reptile (Anderson et al., 2010)

Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook 1: Cognitive Domain, written by Bloom, Engelhart, Furst, Hill and Krathwohl, edited by Bloom, and published in 1956 lighted the way for a lot of educational research. The affective domain was added in 1964, and studies on psychomotor domain were included in 1966 and 1972. The taxonomy was updated with the novelties in 1999 as a result of the studies conducted between 1994 and 1999 (Anderson et al., 2010).

The most used model of educational objectives is based on Ralph Tyler's study (1949, quoted in Anderson et al., 2010). Tyler stated: "The most useful form for stating objectives is to express them in terms which identify both the kind of behavior to be developed in the student and the content or area of life in which this behavior is to operate." In Bloom's updated taxonomy (Revised Bloom's Taxonomy [RBT]), "behavior" is replaced by "cognitive process", and "content" is replaced by "knowledge type" (Anderson et al., 2010).

While the first version of the taxonomy had a single dimension, the revised taxonomy consists of two dimensions. In the updated taxonomy, objectives are listed, and a verb and a noun are incorporated in "objective". While the verb part covers the cognitive process, the noun part is about the knowledge to be learned by students. The table showing the relationship between cognitive process and knowledge is called taxonomy table. The knowledge dimension has four categories: factual, conceptual, procedural, and metacognitive. As some of procedural knowledge is more concrete than conceptual knowledge, which consists of the most abstract knowledge, conceptual and procedural knowledge categories in this dimension may overlap in terms of abstractness. The cognitive process of the table has six categories: remembering, understanding, applying, analyzing, evaluating, and creating (Anderson et al., 2010; Krathwohl, 2002).

Knowledge Dimension

The *Knowledge Dimension* has the following categories and sub-categories as summarized by Anderson et al. (2010):

A. Factual Knowledge: The elements students must know to solve a problem they encounter in a subject area.

B. Conceptual Knowledge: Knowledge in which different pieces of knowledge and parts of pieces of knowledge are connected and integrated in a more systematic way.

C. Procedural Knowledge: Knowledge about "how to do" something. It may often appear as procedures to be followed and steps to be taken in order, but it may also include procedures, skills, algorithms, techniques, and methods that are known together.

While factual knowledge and conceptual knowledge are about answers to "what" questions, procedural knowledge is about answers to "how" question. Differently from metacognitive knowledge, procedural knowledge is limited to skills, algorithms, techniques, and methods specific to a subject or discipline. It represents knowledge or ways of thinking specific to a discipline such as designing and doing experiments in sciences, solving equations of the second degree in mathematics, and historical data collection methods (Anderson et al., 2010).

D. Metacognitive Knowledge: Knowledge of cognition and awareness and knowledge of one's own cognition.

The Cognitive Process Dimension

The permanence of what is learned and increasing its transfer are very important among educational goals. Permanence involves keeping the knowledge in mind and recalling it while transfer requires making out and using what is learned. Permanence puts an emphasis on the past, whereas transfer stresses the future. Constructive learning (learning by understanding) is treated as an important educational objective. At this point, student assessment covers much beyond student's capability to present factual knowledge alone. The cognitive process dimension helps to show the ways in which students can actively engage in learning while trying to construct meaning. The verb part of "objective" is about the cognitive process dimension (Anderson et al. 2010, Krathwohl, 2002). Anderson et al. (2010) summarize the cognitive process dimension as follows:

1. Remembering: Recognizing and recalling.
2. Understanding: Interpreting (clarifying, translating), Exemplifying (illustrating a concept), Classifying (dividing, putting into groups), Summarizing (abstracting, generalizing), Inferring (concluding, extrapolating, predicting, generalizing), Comparing (comparing and contrasting), Explaining (constructing a model representing the cause and effect relationship).
3. Applying: Executing (applying) and Implementing (using).
4. Analyzing (determining the relationship between the part and the whole): Differentiating (distinguishing), Organizing (outlining, structuring), Attributing (ascribing and crediting).
5. Evaluating (making judgments based on criteria and standards): Checking (monitoring, testing), Critiquing (judging).
6. Creating (putting forward a functional whole): Generating (hypothesizing), Planning (designing), Producing (constructing).

Significance of the Study

The study is significant as it provides individuals working in the field of education with an insight into how learning outcomes changed in chemistry curricula in terms of RBT from 2007 to 2018. This study may be supported by research that determines the RBT levels of students at the end of assessment in chemistry courses or the examination of exam questions prepared by teachers for chemistry assessment of students based on RBT.

Taxonomy provides convenience to the practitioner on how the learning outcomes of the curriculum can be gained to pupils and the evaluation of learning outcomes. In the present study, from 2007 to 2018, the leaning outcomes of chemistry curriculum have been handled according to the RBT. This study may give researchers an idea of the changes in learning outcomes in the secondary school chemistry curriculum. It can also help teachers conduct their lessons and prepare exam questions.

Method

The type of the study, target group, data collection tools, validity and reliability, data collection methods, data analysis, limitations should be included in this section. If needed, subheadings can be used in this section.

Research Design

This research was carried out with document analysis which is one of the qualitative research designs. Document analysis involves the analysis of written materials containing information about the phenomenon or phenomena intended to be examined (Yıldırım & Şimşek, 2011). This study examines the chemistry curricula published by the Ministry of National Education of Turkey in 2007, 2013 and 2018 based on the knowledge and cognitive process dimensions of the Revised Bloom's Taxonomy (RBT). In this regard, chemistry curriculum learning outcomes were subjected to content analysis based on the knowledge and cognitive process dimensions of RBT.

Population and Sample/Study Group/Participants

This study examines the chemistry curricula published by the Ministry of National Education of Turkey in 2007, 2013 and 2018 based on the knowledge and cognitive process dimensions of the Revised Bloom's Taxonomy (RBT).

Data Collection Tools

The data collection tool of this study; It consists of a written form in which researchers can be classified the learning outcomes of the 2007, 2013 and 2018 chemistry curricula published by the Ministry of Education in terms of knowledge dimension and cognitive process dimension according to the Revised Bloom Taxonomy (RBT). In the written form, the subtitles of the knowledge dimension and the cognitive process dimension of the RBT have preference boxes. Thus, the researchers had the opportunity to choose the appropriate box. The analysis of the data was done by two researchers who hold the title of Dr. in chemistry education.

Data Collection

The data of the study consisted of the learning outcomes of chemistry curricula published in 2007 2013 and 2018 by the Ministry of Education.

Data Analysis

The RBT dimensions in which chemistry curriculum learning outcomes would be included were determined by both authors separately. In the analysis process, both authors continuously had an exchange of ideas to locate the learning outcomes in the taxonomy and check them. The reliability of results was ensured by detecting agreements and disagreements between the authors through the reliability coefficient formula (Agreements/Agreements+ Disagreements). A reliability coefficient that is not less than 80% is accepted suitable (Miles & Huberman, 1994). In the present study, reliability coefficient was calculated to be 90.57%, which confirmed the reliability of the results.

Table 1 presents examples of chemistry curriculum learning outcomes for the RBT knowledge dimension. The analyses in the knowledge dimension were made considering the examples given in Table 1.

Table 1. Examples from the 2018 Chemistry Curriculum Representing the Knowledge Dimensions

Knowledge Dimension	Examples from the chemistry curriculum
A. Factual Knowledge	S/he *recognizes* basic warning signs used in chemistry for safety purposes.
B. Conceptual Knowledge	S/he *explains* the formation of coal and the types of coal.
C. Procedural Knowledge	S/he *uses* gas laws and kinetic theory to explain the behaviors of gases.
D. Metacognitive Knowledge	S/he *gains awareness of* the limitedness of available water sources in the world.

Table 2 presents examples of chemistry curriculum learning outcomes for the RBT cognitive process dimension. The analyses in the cognitive process dimension were made considering the examples given in Table 2.

Table 2. Examples from the 2018 Chemistry Curriculum Representing the Cognitive Process Dimensions

Cognitive Process Dimension	Examples from the chemistry curriculum
1. Remembering	S/he *matches* the names of elements s/he frequently interacts with in daily life with their symbols**.**
2. Understanding	S/he *explains* the properties of solutions with examples from daily life**.**
3. Applying	She *makes calculations* by connecting the concepts of mass, the number of moles, the number of molecules, the number of atoms, and volume of gases under normal conditions with one another**.**

4. Analyzing	S/he *explains* the importance of sustainable life and sustainable development for society by *establishing a connection* with the science of chemistry**.**
5. Evaluating	S/he *evaluates* the developments in the field of nanotechnology in terms of their effects on science, society, technology, environment, and economy**.**
6. Creating	S/he *puts forward solution suggestions* to decrease the harmful effects of fossil fuels on environment**.**

Research Ethics

We declare that the research has no unethical problem and we observe research and publication ethics.

Findings

This section analyzes 636 learning outcomes of the 2007, 2013, and 2018 chemistry curricula based on the knowledge and cognitive process skills dimensions of RBT and locates them in the taxonomy.

Figure 1 presents the distribution of learning outcomes by year. As showed in Figure 1, 56% (f=354) of the learning outcomes are in the 2007 Chemistry Curriculum, 24% (f=155) in the 2013 Chemistry Curriculum, and 20% (f=127) in the 2018 Chemistry Curriculum.

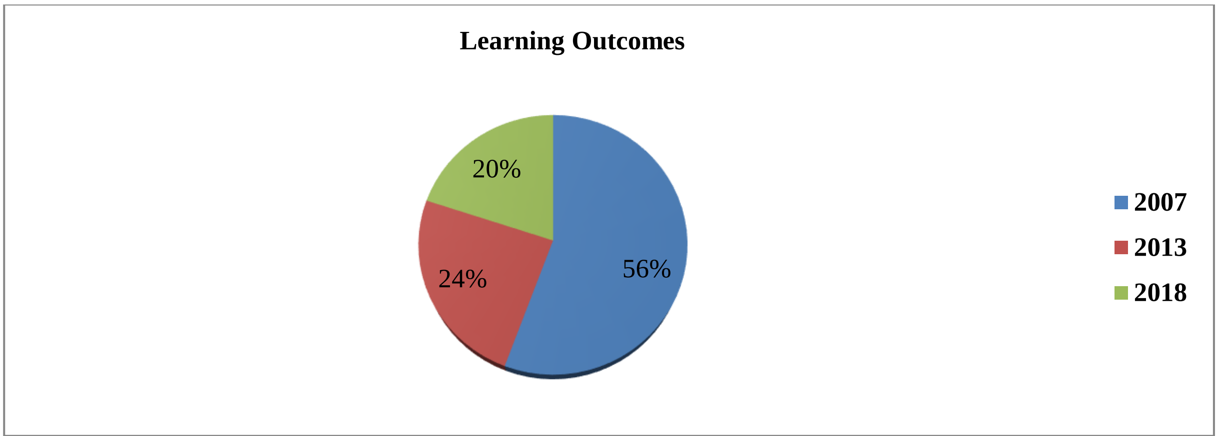

Figure 1. The Distribution of Learning Outcomes in Secondary Education Chemistry Curricula

The distribution of learning outcomes in the knowledge dimension

Table 3 shows the distribution of learning outcomes in the knowledge dimension. As showed in Table 3, 11% (f=70) of knowledge consists of factual knowledge, 70% (f=448) conceptual knowledge, 17% (f=114) procedural knowledge, and 0.48% (f=4) metacognitive knowledge. The table clearly shows that majority (70%) of the learning outcomes are associated with conceptual knowledge.

Table 3. The Distribution of Learning Outcomes in the Knowledge Dimension in Secondary Education Chemistry Curricula

KD	FK	CK	PK	MCK	f	%
2007	45	232	77	0	354	55.66
2013	16	113	22	4	155	24.37
2018	9	103	15	0	127	19.97
f	70	448	114	4	636	
Total Percentage	11.00	70.44	17.93	0.63		100

KD: Knowledge Dimension. FK: Factual Knowledge. CK: Conceptual Knowledge. PK: Procedural Knowledge. MCK: Metacognitive Knowledge.

Figure 2 presents the distribution of learning outcomes in the knowledge dimension based on year. As showed in Figure 2, 12.71% (f=45) of the 2017 learning outcomes, 10.32% (f=16) of the 2013 learning outcomes, and 7.03% (f=9) of the 2018 learning outcomes are in the factual knowledge category, and there is a decrease trend in this category of learning outcomes. 65.54% (f=232) of the 2007 learning outcomes, 72.90% (f=113) of the 2013 learning outcomes, and 81.10% (f=103) of the 2018 learning outcomes are in the conceptual knowledge category, and there is an increase trend in this category of learning outcomes. 21.75% (f=77) of the 2007 learning outcomes, 14.20% (f=22) of the 2013 learning outcomes, and 11.81% (f=15) of the 2018 learning outcomes are in the procedural knowledge category, and there is a decrease trend in this category of learning outcomes. The metacognitive knowledge category is not covered in the 2007 and 2018 chemistry curricula, but 2.58% (f=4) of the 2013 learning outcomes are in the metacognitive knowledge category. There seems to be no considerable change in the metacognitive category of learning outcomes, and almost no coverage is given to this category in the chemistry curricula.

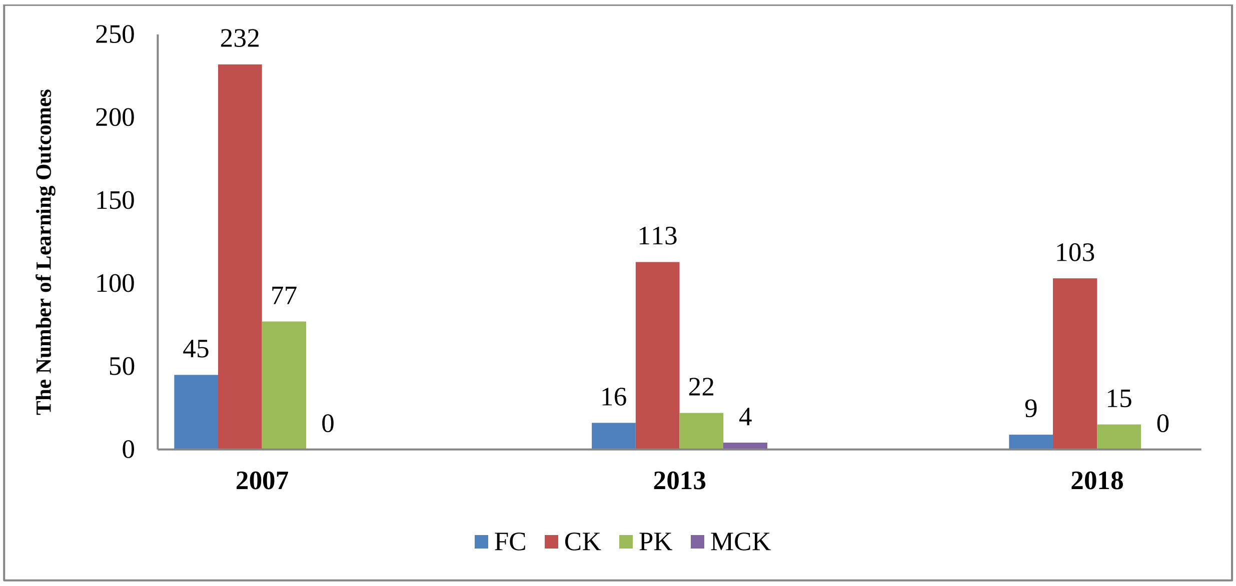

Figure 2. The Distribution of Learning Outcomes in the Knowledge Dimension by Year

Figure 3 presents the distribution of chemistry curriculum learning outcomes in the knowledge dimension by grade. As showed in Figure 3, 12.22% (f=11) of the 2007 ninth-grade learning outcomes, 24.24% (f=8) of the 2013 ninth-grade learning outcomes, and 7.89% (f=3) of the 2018 ninth-grade learning outcomes are in the factual knowledge category; 13.92% (f=11) of the 2007 tenth-grade learning outcomes, 7.69% (f=3) of the 2013 tenth-grade learning outcomes, and 2.57% (f=1) of the 2018 tenth-grade learning outcomes are in the factual knowledge category; 5.33% (f=4) of the 2007 eleventh-grade learning outcomes, 4.35% (f=2) of the 2013 eleventh-grade learning outcomes, and 0% (f=0) of the 2018 eleventh-grade learning outcomes are in the factual knowledge category; and 12.27% (f=9) of the 2007 twelfth-grade learning outcomes, 8.11% (f=3) of the 2013 twelfth-grade learning outcomes, and 16.13% (f=5) of the 2018 twelfth-grade learning outcomes are in the factual knowledge category. 67.78% (f=61) of the 2007 ninth-grade learning outcomes, 57.57% (f=19) of the 2013 ninth-grade learning outcomes, and 91.30% (f=21) of the 2018 ninth-grade learning outcomes are in the conceptual knowledge category; 70.89% (f=56) of the 2007 tenth-grade learning outcomes, 82.05% (f=32) of the 2013 tenth-grade learning outcomes, and 91.30% (f=21) of the 2018 tenth-grade learning outcomes are in the conceptual knowledge category; 74.67% (f=56) of the 2007 eleventh-grade learning outcomes, 76.09% (f=35) of the 2013 eleventh-grade learning outcomes, and 85.71% (f=30) of the 2018 eleventh-grade learning outcomes are in the conceptual knowledge category; and 53.64% (f=59) of the 2007 twelfth-grade learning outcomes, 72.97% (f=27) of the 2013 twelfth-grade learning outcomes, and 70.97% (f=22) of the 2018 twelfth-grade learning outcomes are in the conceptual knowledge category. 20.00% (f=18) of the 2007 ninth-grade learning outcomes, 12.12% (f=4) of the 2013 ninth-grade learning outcomes, and 13.16% (f=5) of the 2018 ninth-grade learning outcomes are in the procedural knowledge category; 15.19% (f=12) of the 2007 tenth-grade learning outcomes, 7.69% (f=3) of the 2013 tenth-grade learning outcomes, and 4.35% (f=1) of the 2018 tenth-grade learning outcomes are in the procedural knowledge category; 20.00% (f=15) of the 2007 eleventh-grade learning outcomes, 19.56% (f=9) of the 2013 eleventh-grade learning outcomes, and 14.29% (f=5) (f=30) of the 2018 eleventh-grade learning outcomes are in the procedural knowledge category; and 29.09% (f=32) of the 2007 twelfth-grade learning outcomes, 16.22% (f=6) of the 2013 twelfth-grade learning outcomes, and 12.90% (f=4) of the 2018 twelfth-grade learning outcomes are in the procedural knowledge category.

As showed in Figure 3, none of the learning outcomes in the 2007 and 2018 chemistry curricula are in the metacognitive category. In 2013, on the other hand, coverage, though little, was given to the metacognitive category in the ninth (f=2; 6.07%), tenth (f=1; 2.57%), and eleventh (f=1; 2.70%) grades.

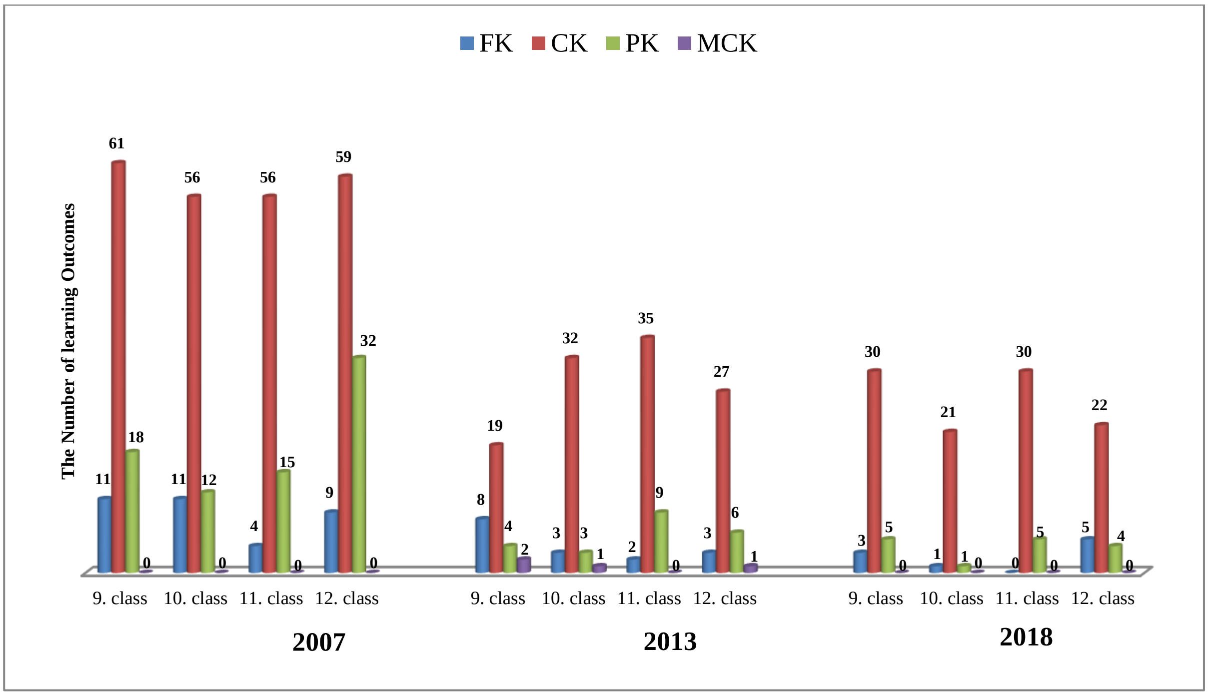

Figure 3. The Distribution of Chemistry Curriculum Learning Outcomes in the Knowledge Dimension by Grade

The distribution of learning outcomes in the cognitive process dimension

Table 4 shows the distribution of learning outcomes in the cognitive process dimension. As showed in Table 4, 7.86% (f=50) of learning outcomes consist of remembering, 60.53% (f=385) understanding, 12.58% (f=80) applying, 16.98% (f=16.98) analyzing, 0.64% (f=4) evaluating, and 1.41% (f=9) creating. The table clearly shows that majority (70 %) of the learning outcomes are in understanding cognitive process category.

Table 4. The Distribution of Learning Outcomes in the Cognitive Process Dimension in Secondary Education Chemistry Curricula

CPD	2007	2013	2018	f	%
R	33	10	7	50	7.86
U	226	67	92	385	60.53
AP	60	10	10	80	12.58
AN	35	60	13	108	16.98
E	0	2	2	4	0.64
C	0	6	3	9	1.41
f	354	155	127	636	
Total Percentage	55.66	24.37	19.97		100

CPD: Cognitive Process Dimension. R: Remembering, U: Understanding, AP: Applying, AN: Analyzing, E: Evaluating, C: Creating.

Figure 4 presents the distribution of learning outcomes in the cognitive process dimension by year. As showed in Figure 4, 9.32% (f=33) of the 2007 learning outcomes, 6.45% (f=10) of the 2013 learning outcomes, and 5.51% (f=7) of the 2018 learning outcomes are in the remembering category. 63.84% (f=226) of the 2007 learning outcomes, 43.33% (f=67) of the 2013 learning outcomes, and 72.44% (f=92) of the 2013 learning outcomes are in the understanding category. 16.95% (f=60) of the 2007 learning outcomes, 6.45% (f=10) of the 2013 learning outcomes, and 7.87% (f=10) of the 2018 learning outcomes are in the applying category. 9.89% (f= 35) of the 2007 learning outcomes, 38.71% (f=60) of the 2013 learning outcomes, and 10.24% (f=13) of the 2013 learning outcomes are in the analyzing category. None of the 2007 learning outcomes are in the evaluating category while 1.29% (f= 2) of the 2013 learning outcomes and 1.57% (f=2) of the 2018 learning outcomes are in the evaluating category. Also, none of the 2007 learning outcomes are in the creating category while 3.87 % (f=6) of the 2013 learning outcomes and 2.36 (f=3) of the 2018 learning outcomes are in the creating category. Figure 4 clearly shows that the understanding category dominates the 2007, 2013, and 2018 chemistry curricula, whereas there are serious lacks in high-level cognitive process dimensions such as evaluating and creating.

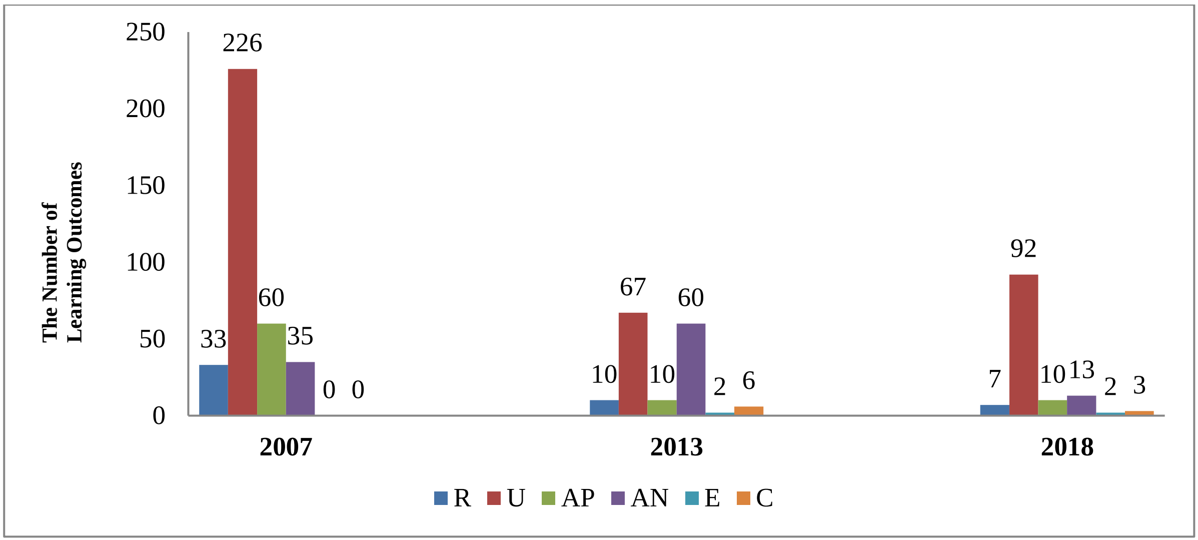

Figure 4. The Distribution of Learning Outcomes in the Cognitive Process Dimension by Year

Figure 5 presents the distribution of chemistry curriculum learning outcomes in the cognitive process dimension by grade. As showed in Figure 5, 6.67% (f=6) of the 2007 ninth-grade learning outcomes, 9.09% (f=3) of the 2013 ninth-grade learning outcomes, and 7.89% (f=3) of the 2013 ninth-grade learning outcomes are in the remembering category. 12.66% (f=10) of the 2007 tenth-grade learning outcomes and 7.69% (f=3) of the 2013 tenth-grade learning outcomes are in the remembering category, but none of the 2018 tenth-grade learning outcomes are in this category. 4.00% (f=3) of the 2007 eleventh-grade learning outcomes and 4.35% (f=2) of the 2013 eleventh-grade learning outcomes are in the remembering category, but none of the of the 2018 eleventh-grade learning outcomes are in this category. 3.64% (f=4) of the 2007 twelfth-grade learning outcomes, 5.41% (f=2) of the 2013 twelfth-grade learning outcomes, and 12.90% (f=4) of the 2018 twelfth-grade learning outcomes are in the remembering category. 66.67% (f=60) of the 2007 ninth-grade learning outcomes, 60.61% (f=20) of the 2013 ninth-grade learning outcomes, and 70.05% (f=27) of the 2013 ninth-grade learning outcomes are in the understanding category. 64.56% (f=51) of the 2007 tenth-grade learning outcomes, 47.72% (f=19) of the 2013 tenth-grade learning outcomes, and 95.65% (f=22) of the 2018 learning outcomes are in the understanding category. 66.67% (f=50) of the 2007 eleventh-grade learning outcomes, 30.96% (f=17) of the 2013 eleventh-grade learning outcomes, and 74.29% (f=26) of the 2018 eleventh-grade learning outcomes are in the understanding category. 59.09% (f=65) of the 2007 twelfth-grade learning outcomes, 29.73% (f=11) of the 2013 twelfth-grade learning outcomes, and 54.84% (f=17) of the 2018 twelfth-grade learning outcomes are in the understanding category. 18.89% (f=17) of the 2007 ninth-grade learning outcomes, 3.03% (f=1) of the 2013 ninth-grade learning outcomes, and 7.89% (f=3) of the 2013 ninth-grade learning outcomes are in the applying category. 12.69% (f=10) of the 2007 tenth-grade learning outcomes and 5.13% (f=2) of the 2013 tenth-grade learning outcomes are in the applying category, but none of the 2018 learning outcomes (f=0) are in this category. 20.00% (f=15) of the 2007 eleventh-grade learning outcomes, 10.20% (f=5) of the 2013 eleventh-grade learning outcomes, and 11.43% (f=4) of the 2018 eleventh-grade learning outcomes are in the applying category. 16.36% (f=18) of the 2007 twelfth-grade learning outcomes, 5.41% (f=2) of the 2013 twelfth-grade learning outcomes, and 9.68% (f=3) of the 2018 twelfth-grade learning outcomes are in the applying category. 7.78% (f=7) of the 2007 ninth-grade learning outcomes, 24.24% (f=8) of the 2013 ninth-grade learning outcomes, and 7.89% (f=3) of the 2013 ninth-grade learning outcomes are in the analyzing category. 10.13% (f=8) of the 2007 tenth-grade learning outcomes, 28.20% (f=11) of the 2013 tenth-grade learning outcomes, and 4.35% (f=1) of the 2018 tenth-grade learning outcomes are in the analyzing category. 9.33% (f=7) of the 2007 eleventh-grade learning outcomes, 43.48% (f=20) of the 2013 eleventh-grade learning outcomes, and 14.29% (f=5) of the 2018 eleventh-grade learning outcomes are in the analyzing category. 11.81% (f=13) of the 2007 twelfth-grade learning outcomes, 57.76% (f=21) of the 2013 twelfth-grade learning outcomes, and 12.90% (f=4) of the 2018 twelfth-grade learning outcomes are in the analyzing category. None of the 2007 learning outcomes are in the evaluating category, and very few of the 2013 ninth-grade (3.03%, f=1) and tenth-grade (2.56%, f=1) learning outcomes and the 2018 twelfth-grade (6.45%, f=2) learning outcomes are in the evaluating category. Also, none of the 2007 learning outcomes are in the creating category, and very few of the 2013 tenth-grade (7.69%, f=3), eleventh-grade 4.36%, f=2), and twelfth-grade 2.70%, f=1) and the 2018 ninth-grade (5.26%, f=2) and twelfth-grade (3.23%, f=1) learning outcomes are in the creating category.

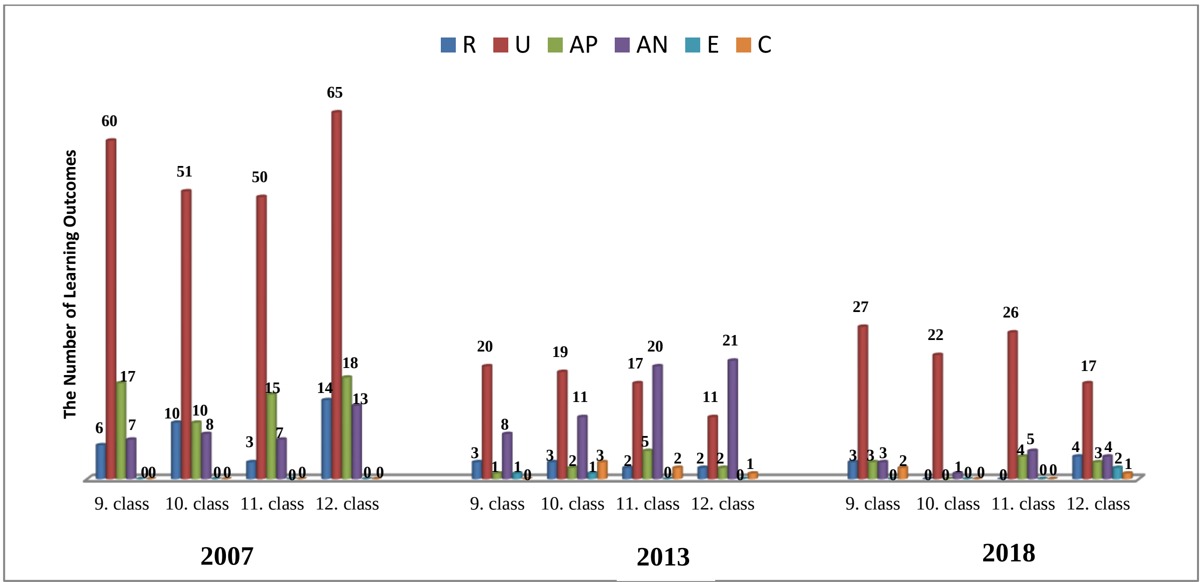

Figure 5. The Distribution of Learning Outcomes in the Cognitive Process Dimension by Year and Grade

Discussion and Conclusion

The study showed that chemistry curriculum learning outcomes had a considerable decrease from 2007 to 2018 (Figure 1). They were considerably simplified. This is in line with 'keeping short provides the essence' principle. It is possible to say that the aim is to provide meaningful learning by introducing basic concepts instead of overloading students with much information (Çepni & Çil, 2016). Moreover, the decrease in the number of learning outcomes given in the curriculum provides convenience for teachers as the number of class hours per learning outcome will increase, and it will be easier to transform learning outcomes into behaviors (Karatay, Timur & Timur, 2013).

The main aim of building up a taxonomy of educational objectives is to facilitate communication (Bloom, et al., 1956). The findings of the study indicate that chemistry curriculum learning outcomes in the knowledge dimension are rather about conceptual knowledge (Table 3). The distribution of learning outcomes in the knowledge dimension over years shows that the coverage of factual knowledge and procedural knowledge decreased from 2007 to 2018 while that of conceptual knowledge increased. It was also seen that the metacognitive knowledge category was not covered in 2007 and in 2018 whereas it is possible to trace metacognitive knowledge in 2013, though at a very low level (Figure 2). It is clear that there has not been a significant change in the metacognitive knowledge category. The distribution of factual knowledge outcomes by grade shows that factual knowledge outcomes in the ninth grade increased from 2007 to 2013 while there was a decrease from 2013 to 2018. For the tenth and eleventh grades, factual knowledge decreased from 2007 to 2018. Finally, for the twelfth grade, there was a decrease from 2007 to 2013, while there was an increase from 2013 to 2018. The distribution of conceptual knowledge outcomes by grade shows that there was a decrease from 2007 to 2013 for the ninth grade, while there was an increase from 2013 to 2018. However, this does not mean that there was a significant decrease in the conceptual knowledge category. Instead, it means that there was a decrease in the increase of the coverage of conceptual knowledge. Conceptual learning outcomes increased for the tenth and eleventh grades from 2007 to 2018. For the twelfth grade, there was an increase from 2007 to 2013, while there was a decrease from 2013 to 2018, though slightly. However, this does not mean that there was a decrease in the coverage of conceptual knowledge, rather there was a decrease in the amount of the increase. It is possible to say that there is an overall increase in conceptual learning outcomes by grade. The distribution of procedural dimension learning outcomes by grade shows that there was a decrease from 2007 to 2018 for the ninth, tenth, eleventh, and twelfth grades. However, there was not a significant change in the coverage of metacognitive knowledge by grade, and this is an important lack (Figure 3).

Considering the chemistry curriculum as a whole and the cognitive process dimension, it can be concluded that the majority of learning outcomes are in the understanding category (Table 4). From 2007 to 2018, chemistry curriculum learning outcomes in the cognitive process dimension experienced a decrease in the remembering and applying categories, whereas there was an increase in the understanding category. The analyzing category seems fluctuating as there was a significant increase in 2013 compared to 2007; however, there was a significant decrease in 2018 compared to 2013. The evaluating and creating categories were not covered in 2007 though they were included in learning outcomes in 2013 and 2018, though at a low level, which was not sufficient (Figure 4). The distribution of chemistry curriculum learning outcomes in the cognitive process dimension by grade shows that there was not a significant increase or decrease in the remembering category for the ninth grade in 2007, 2013, and 2018. For the tenth and eleventh grades, there was a slight decrease in the remembering category from 2007 to 2018. As for the twelfth grade, there was a slight increase in the coverage of the remembering category from 2007 to 2018. There was a decrease in that of the understanding category from 2007 to 2013 for all grades, whereas there was an increase from 2013 to 2018. However, majority of the learning outcomes were in the understanding category for all grades. In the applying category, there was a decrease from 2007 to 2013 and an increase from 2013 to 2018 for the ninth, eleventh, and twelfth grades. However, for the tenth grade, there was a decrease from 2007 to 2013, and the applying category was not covered in 2018. There was a significant increase from 2007 to 2013 in the analyzing category for the ninth, tenth, eleventh, and twelfth grades while there was a significant decrease from 2013 to 2018. The evaluating category was not covered in 2007, while only a few learning outcomes were about the evaluating category in 2013 for the ninth grade (3.03%, f=1) and the tenth grade (2.56%, f=1), and a few were about this category in 2018 for the twelfth grade (6.45%, f=2), all indicating very low levels. Moreover, none of the learning outcomes in 2007 were about the creating category, and only a few were about this category in 2013 for the tenth grade (7.69%, f=3), eleventh grade (4.36%, f=2), twelfth grade (2.70%, f=1) and in 2018 for the ninth grade (5.26%, f=2) and the eleventh grade (3.23%, f=1), indicating also very low levels (Figure 5).

To conclude, the distribution of chemistry curriculum learning outcomes by year and grade shows that the knowledge dimension mostly covers the conceptual category, and the cognitive process dimension mostly covers the understanding category. Moreover, learning outcomes covering procedural and metacognitive categories of the knowledge dimension and learning outcomes covering the evaluating and creating categories of the cognitive process dimension are either very few or non-existent. This is a very important lack. These results are in line with the results of Zorluoğlu, Kızılaslan and Sözbilir (2016), Yaz and Kurnaz (2017), Zorluoğlu, Şahintürk and Bağrıyanık (2017), Cangüven, Öz, Binzet and Avcı (2017), Zorluoğlu, Güven and Korkmaz (2017), and Eke (2018). Zorluoğlu, Kızılaslan and Sözbilir (2016) analyzed the learning outcomes of the chemistry curriculum for 2013 while Zorluoğlu, Güven and Korkmaz (2017) analyzed the learning outcomes in the 2017 curriculum based on RBT. These studies report that most of learning outcomes in 2013 and 2017 curricula are about conceptual knowledge in the knowledge dimension and that learning outcomes are low-level in the cognitive process dimension, with the outcomes mostly focusing on remembering, understanding, and applying. They state that very little coverage is given to learning outcomes covering high-level cognitive processes such as evaluating and creating. Zorluoğlu, Şahintürk and Bağrıyanık (2017) and Yaz and Kurnaz (2017) studied draft 2013 science curriculum outcomes while Cangüven, Öz, Binzet and Avcı (2017) studied draft 2017 science curriculum outcomes based on RBT. These studies also yielded similar results. The 2013 science curriculum learning outcomes mostly concentrated on conceptual knowledge in the knowledge dimension while fewest learning outcomes were about metacognitive knowledge. In the cognitive process dimension, learning outcomes were mostly about the understanding category while fewest learning outcomes covered high-level cognitive processes such as evaluating and creating. Similarly, draft 2017 science curriculum learning outcomes were mostly about understanding, which is a low-level cognitive process. Eke (2018) analyzed the 2018 physics curriculum learning outcomes based on RBT. That study also revealed that most of the learning outcomes were about conceptual knowledge in the knowledge dimension and about understanding in the cognitive process dimension. These results indicate that learning outcomes for the science, physics, and chemistry courses are mostly low-level, concentrating on conceptual knowledge and understanding.

The taxonomy approach not only helps teachers understand and observe the learning outcomes of curricula but also guides them through their efforts to prepare questions that will assess students (Anderson et al., 2010). Learning becomes more effective and meaningful when students seek answers to the questions they face (Koray, Altunçekiç & Yaman, 2005). The quality of questions that will assess students is of importance. In this sense, teachers' question preparing skills are important as well. The results obtained from certain previous studies in the literature dwelling on Bloom's Taxonomy, Revised Bloom's Taxonomy, and assessment in the teaching process are given below. Similar results were also obtained with these studies. Koray, Altunçekiç and Yaman (2005) studied preservice science teachers' question-asking skills. They reported that preservice science teachers' skills of asking knowledge and comprehension questions are better than their skills of asking questions in other areas. Dindar and Demir (2006) analyzed fifth grade teachers' science exam questions based on Bloom's Taxonomy. They ascertained that 65% of the questions were at the knowledge level. Ayvacı and Türkdoğan (2010) studied science and technology teachers' written exam questions based on RBT. They revealed that 38.8% of the questions covered factual knowledge in the knowledge dimension and 38% were in the conceptual knowledge dimension, whereas 38.4% were associated with remembering, 16.3% understanding, 8.5% analyzing, 23.1% evaluating, and 0.5% creating in the cognitive process dimension. Özcan and Oluk (2007) dealt with the sixth, seventh, and eighth grade science teachers' written exam questions based on Bloom's Taxonomy. They determined that 39% of the questions were at the knowledge level, 25% at the comprehension level, 32% at the application level, and 4% at the analysis and synthesis stages. Gündüz (2009) scrutinized the sixth, seventh, and eight grade science and technology teachers' written exam questions and detected that 64.65% of the questions were at the knowledge level, 9.68% at the comprehension level, 17.86% at the application level, 4.51% at the analysis level, 0.94% at the synthesis level, and 2.34% at the evaluation level.

Previous studies show that science teachers' exam questions are rather low-level based on Bloom's Taxonomy or Revised Bloom's Taxonomy. The analysis on the learning outcomes of curricula as well as the questions asked by teachers show that the outcomes and the questions are rather low-level based on Bloom's Taxonomy or Revised Bloom's Taxonomy. The Revised Bloom's Taxonomy guides academics and teachers through preparation of curricula and teaching and assessment of courses. In-service trainings may be provided for teachers to better understand the curricula prepared based on Bloom's Taxonomy and to use the taxonomy more consciously in their courses. In addition, preservice teachers studying in faculties of education may be equipped with elaborated awareness on various course contents (curriculum development, assessment and evaluation, teaching practice, etc.).

Acknowledgments

This research was presented at the 6. Congress of Chemistry Education, Ankara, Turkey 2-4 May 2019.

Statement of Publication Ethics

We (The authors) declare that the research has no unethical problems and we observe research and publication ethics.

Conflict of Interest

The study has no conflict of interest.

Researchers' Contribution Rate

Authors	Literature review	Method	Data Collection	Data Analysis	Results	Conclusion
Mehmet DiyaddinYaşar	☒	☒	☒	☒	☒	☒
Sibel Sadi Yılmaz	☒	☒	☒	☒	☒	☒

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Appendix 1:

Bartın University Journal of Faculty of Education
The Ethical Issues Declaration Form For Authors

Article Title	Analysis, Evaluation and Comparison of the 2007, 2013 and 2018 Chemistry Curriculum Learning Outcomes Based on the Revised Bloom's Taxonomy
Discipline	Chemistry education
Type of Article	Research article
Year of Data Collection	2019

As the author of the article, I declare in this form that scientific and ethical rules are followed in this article and that the article does not require the permission of ethical committee for the reason that the data collected through document analysis in 2019.

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