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Awareness and Perceptions towards Practices of Twenty-First Century Skills in Chemistry Education in the Secondary Schools

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Abstract

The aim of this study was to determine chemistry teachers' and students' level of awareness, perceptions, attitudes, and practices of twenty-first century skills (21st-CS) in chemistry education in the government secondary schools (grades 9 & 10) of Addis Ababa City Administration. The high school students of developing countries were not being taught as 21st learning required. Students learn the abstract concepts of chemistry with pure lecture and teachers struggle with pen and pencil, chalk and backboard to teach the theoretical concepts of chemistry. The mixed methods embedded design was employed in data collection and analysis. The chemistry teachers and students had moderate awareness, high perceptions, high and positive attitudes towards practices of 21st-CS. Despite practices of 21st-CS were only moderate among participants. However, the descriptive statistics results not substantiated by the qualitative results.

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These imply that the implementation of 21st-CS had not get equal emphasis as content knowledge. This research findings inform all levels of education actors from school to Ministry of Education about implementation of 21st-CS in secondary schools to give equal emphasis for both content knowledge and soft skills.

Keywords: Attitude; Awareness; Chemistry education; Mixed methods; Perception; Secondary school; 21st-century skills.

1. Introduction

The skills needed in the fourth industry (4.0) that every individual and collective has mostly referred to as twenty-first century skills [1, 2]. In this study, twenty-first century skills (21st-CS) is defined as a broad set of skills that integrate non-routine cognitive skills, non-cognitive inter- and intra-personal skills, and information, technology, and digital (ITD) literacy skills that enable ever learner's to learn, perform well, accomplish the desired goals, overcome challenges, and to navigate in the digital age. This new learning approach can be accelerated, decelerated or retarded by different factors. However, according to researchers' assumption awareness, perceptions and attitudes play a critical role to implement 21st-CS in the classroom as well as outside. With this vein, motivation, favorable perceptions, and positive attitudes towards learning are crucial to achieve the desired learning outcomes. Motivation can be favored through awareness creation. Awareness suppresses unfavorable perceptions and negative attitudes towards achieving the indented objective (s). Awareness refers to being conscious, familiar, knowledgeable, or informed about the 21st century learning skills, teachers' and students' characteristics in the 21st century.According to the authors [3], perception refers to how people understand and perceive their environment. It has a significant impact on how people accept, understand, and respond to information. In this study, perception refers to the thinking of teachers and students about learning of 21st-CS integration with chemistry education. Favorable perceptions arose motivation, commitment, and excellent learning situations, whereas unfavorable perceptions can obstruct the practices of 21st-CS. Practices refer to the way chemistry teachers and students are acting to implement 21st-CS integrating with chemistry lessons. According to the author [4], our perceptions and thoughts influence our actions and words. This has an impact on mindset. A teacher's role in the teaching-learning process is to facilitate students' learning. Students see a variety of instructional strategies and approaches from teachers, which could be advantageous or detrimental to their relationship. Positive attitudes encourage mental readiness to change through learning, erase frustration, and any negative connotations associated with something, whereas negative attitudes discourage, restrict, and even suppress learning (Congos & Dennis) as cited in [5].In January 2018, the Ministry of Education of the Federal Democratic Republic of Ethiopia has developed a concept note to achieve the country's vision, ensuring sustainable development, and promoting lifelong learning in the context of the twenty-first century [6]. In order to align curricula with the global economy, the Ethiopian government has reviewed the KG–12 curriculum and incorporated some domains of 21st-CS into the curriculum framework and education policy in 2021 [7]. In the new Ethiopian secondary school (SS) curriculum chemistry offered as a subject from grades 9 through 12. According to Award [8], chemistry is both a creative science and the fundamental basis for the sustainable advancement of our way of life. Since chemistry is an integral part of both the environment and life. To tackle the complex issues facing our world, a mere understanding of chemistry concepts is insufficient. This in turns integration of 21st-CS with chemistry contents help students to understand the concepts deeply and increase students’ motivation in learning of chemistry [9]. Also, help them to relate the chemistry concepts with their daily life experiences and the real world.Nevertheless, learning by doing is neglected, and teachers struggle to teach the theoretical concepts of chemistry to students using a pen and pencil, chalkboard, and whiteboard. Students acquire the abstract concepts of chemistry through talk and chalk [10]. 21^{st}-CS/soft skills are a relatively new area of learning and have recently gained emphasis in Ethiopian curricula. These served as the impetus for the researchers' investigation into teachers and students' awareness, perceptions, and attitudes towards particles of 21^{st}-CS such as creative and critical thinking, problem solving, complex communication, collaboration, information literacy, technology literacy, and digital literacy in chemistry education. Therefore, the purpose of this study was to answer the research questions: (1) what is the level of awareness, perceptions, attitudes and practices of 21^{st}-CS in chemistry education among chemistry teachers’ and students’? (2) Is there a significant differences in level of awareness, perceptions, attitudes, and practices of 21^{st}-CS in chemistry education among teachers’ and students’? (3) What is the relationship between awareness, perceptions, attitudes and practices of 21^{st}-CS in chemistry education?

2. Theoretical Framework

Theoretical framework refers to the larger assumptions of concepts or theories in which the work relay on to determine the relationships among variables in 21^{st} century learning skills.

2.1. Constructivist learning theory

According to Golder [11], constructivist teaching is based on the belief that knowledge is best acquired by students through active learning and exploration. This means that students acquire knowledge when they fully involved in learning through different student-centered teaching methods. When teacher’s used effective teaching methods students take more responsibility for learning than simply receiving information from their teacher. In such case the roll of teacher’s has shifted to facilitation for students learning than transmitter of knowledge. Regarding this, Golder [11] explained that teacher act as facilitator, coach, guider, mediate, prompt, assister, provoker, co-explore and assessors to develop and understanding students learning. Such techniques provide opportunities for students to engage in critical and creative thinking, analysis, and synthesis of ideas and motivate students to search, challenge, and formulate their own thinking, views, and conclusions. The author [12] stated that in social constructivist viewpoints hold that cognitive development is maintained by social processes rather than an individual. With this context, students can learn more when they interact with technologies, other learners, their teacher, other experts and learning materials. In implementing effective teaching strategies, students can learn new information and skills, and collaborate with one another rather than working alone. The target of learning must student-centered (students get opportunities to ‘‘learn by doing’’ within the classroom as well as outside.

2.2. Connectivist learning theory

According to Connectivist learning theory students’ exchange of knowledge through a network of humans and non-humans (concrete conveyors). Which means that learning is actionable knowledge that can be found out of human mind or in a database. In the digital world students will learn from anywhere, anytime by making connection or plug in to social interaction, flows of information/exchange of knowledge [13, 14, 15]. This helps students to develop 21st-CS and acquire the same science knowledge that taught elsewhere at any time. Get chance to observe virtually abstract chemistry concepts, and share of information with experts and other students. This requires selecting best instructional materials (technological tools) for matching content and effective strategies of teaching- learning process.

2.3. Theory of multiple intelligence

The theory of multiple intelligences (MI) encourage personalized learning, considering that depending on their intelligences (i.e., strengths) students can involve actively in learning. Nine common types of intelligences are identified by Gardner (2011a), as cited in McFarlane [16]. Such as verbal-linguistic, logical-mathematical, musical-rhythmic, bodily-kinesthetic, visual-spatial, interpersonal, intrapersonal, naturalist and existential intelligence (the detail application of MI theory explained in authors [16, 17, 18]. Mead [19] has mentioned seven distinct learning styles, namely visual (learn best via pictures and images), auditory (learn best via sound and music), verbal (learn best via speech and writing), physical (learn best via hands-on method), logical (learn best via reasoning), social (learn more when discussed with others), and solitary (learn more by own pace) that corresponding to students intelligences. In addition, the diversity of the world's societies today is more apparent than it was in the past. The classroom of the 21st-century and the wider community both reflect this diversity. Thus, chemistry teachers should assess their students' intelligences (i.e., understand their areas of strength) to design lessons and use suitable pedagogies to engage students in their learning style to foster 21st-CS. Since each student has unique preferences for learning. Also chemistry teachers should fully understand that the process of teaching 21st-CS, such as , creative and critical thinking effective communication, collaboration, complex problem solving, etc. are not a straightforward as content knowledge.

With the aforesaid context, teachers should apply constructivism learning perspectives and connectivism learning approach to address the need of 21st century learning using effective teaching method that promote student-centered method. To participate students in learning of 21st-CS in sciences different appropriate teaching methods were suggested by scholars, such as brainstorming, case study, discovery learning, and inquiry- and project-based learning, flipped classroom learning, mind maps, discussion, game based learning [20, 21,33]. These teaching methods involves the social interaction (i.e., interaction among teacher and students, student with each other, and parent and students) and learning environment (student-lessons and student-artifacts interactions). In this study an artifact is a human-made object or piece of software that is specifically used in the teaching and learning process of sciences, particularly in chemistry, or something that is observed in an experiment or scientific investigation that is not naturally occurring but results from the preparatory or investigative process.

3. Materials and methods

3.1. Research design

The mixed methods embedded research design was used in data collection process and analysis. According to Creswell [22], the goal of an embedded design is to gather both quantitative and qualitative data either concurrently or sequentially, with one type of data serving as a support system for the other.

3.2. Research method

The techniques that researchers employ for data collection, analysis, and interpretation are known as research methods [23]. Mixed methods research was employed in data collection, and analysis. Because either the qualitative or quantitative approach by itself is inadequate to best understand a research problem. The mixed methods support each other in filling the limitation observed in one of the methods and assist the researcher to explore the problems in depth. In light of this, the researchers first collected qualitative data by watching classes while concurrently gathering data from secondary sources (such as daily lesson plan, various assessments, attendance, table of specifications, and mark list reporting format) from the teachers. Following the takeover of classroom observation, quantitative data were gathered using questionnaires. Finally, focus group discussions (FGD) and interviews were held.

3.3. Sample size and target population

Addis Ababa a total of 78 government SSs are spread across 11 sub-cities under City Administration, which comprises 35,046 boys and 41,821 girls make up total of 76,867 regular students enrolled in grades 9 and 10. Multi-stage random sampling was used to choose samples of student respondents. The challenge of obtaining

a full sampling frame of SSs students in Addis Ababa City administration has led to the selection of this sampling technique. It would also be extremely difficult, expensive, and time-consuming to gather data from a sample of students throughout the city. The researchers were employed multistage sampling to get around these obstacles. A Total of 15 government SSs were selected using lottery method. The number of students were 13,749, which comprises 6,404 boys and 7,345 girls. By Using Krejcie and Morgan [24] known population size formula student participant were determined. Chemistry teachers of grades 9 and 10 were chosen using the available sampling method due to their small population size in the selected SSs. A total of 819 chemistry teachers (663 males and 156 females) teaching in grades 9 and 10 across the 11 sub-cities. In the 15 selected SSs totally, 81 chemistry teachers (62 males and 19 females). A total of 463 participants were chosen to take part in this study.

3.4. Validity of research tools

Validity defined as the degree to which the research instrument measures what it is intended to measure [25]. Qualitative content validity was done using cognitive interview. A cognitive interview was conducted with six member FGD that lasted 1:30 hours to evaluate their understanding of survey questions with a combination of both the think-aloud and verbal probing. During FGD notes were taken by identify issues into: (1) no problem with the item; (2) minor misunderstanding with the item (e.g., concept, word, phrase); and (3) item unclear.

The quantitative content validity (CV) was done through analysis of content validity index (CVI). The CVI can be calculated using item-level content validity index (I-CVI) and scale-level content validity index (S-CVI). Values of CV range from 0 to 1, where for I-CVI < 0.70 the item removed, 0.70 – 0.78 the item needs revisions and ≥ 0.79 the item should remain [26]. Pre-pilot test of I-CVI of awareness, perceptions and attitudes were ranged each from 0.78 to 1.0 for 6 items, whereas I-CVI of practices of 21^{st}-CS was ranged from 0.44 to 1.00 for 6 items. Three items in perceptions and attitudes a value of I-CVIs were 0.78 need revision. Two items in awareness and practices of 21^{st}-CS an I-CVI value of 0.78 need revision and one item a score of 0.44 was removed from practices of 21^{st}-CS. Based on comments, suggestions and information gained through cognitive interview and experts' judgment the developed questions were revised and all the items were restated, and post-pilot test was conducted. The result of post-pilot test of the three domains (awareness, perceptions and attitudes) each have 6 items, and practices of 21^{st}-CS has 5 items, a total of 23 items values of CVIs were found in acceptable range of 0.80 to 1.00 (high to very high).

3.1. Reliability of research tools

Internal consistency reliability is a measure of consistency between different items of the same construct. A general rule for interpreting Cronbach's alpha is $\propto \geq 0.9$ is excellent, $0.9 > \propto \geq 0.8$ is good, $0.8 > \propto \geq 0.7$ is acceptable, $0.7 > \propto \geq 0.6$ is questionable, $0.6 > \propto \geq 0.5$ is poor and $0.5 > \propto$ is unacceptable. In general, $\propto$ a 0.70 or larger score is considered an acceptable level [27]. The pre-pilot test values of $\propto$'s for awareness, perception, attitude, and practices of 21^{st}-CS were 0.858, 0.859, 0.906, and 0.899, respectively. The post- pilot test values of $\propto$'s for the four domains were 0.947, 0.923, 0.955, and 0.936, respectively.

3.1. Data analysis

The collected data were organized in Microsoft Excel and run using IBM SPSS Statistics version 27.0.1. Descriptive statistics, such as the number, mean, and standard deviation were used to determine the level of the four domains. Inferential statistics such as Jonckheere-Terpstra Test was used to analysis the differences in level of three domains respect to practices of 21^{st}-CS and Kendall's tau-b correlation test was used to analysis the significance of association between the four domains. Qualitative data were analyzed in narrative way.

4. Results

Table 1 showed the survey questions' response rate. The survey questions were returned by every student participant, all of the responses were accepted. Ninety-five percent of the survey questions were returned from chemistry teachers. However, 90% of the survey questions that were filled out were accepted. Initially, four chemistry teachers were not returned the survey questions.

Table 1: Response rate

Respondent	Population	Sample Size	Returned Questionnaires	Return Rate in %	Valid Returned Questionnaires
Chemistry teachers	819	81	77	95.06	73 (90.12 %)
Grade 9 students	39,001	191	191	100	191 (100 %)
Grade 10 students	37,866	191	191	100	191 (100 %)
Total	76,867	463	459	99.14	455 (98.27 %)

Prior to data processing, four of the returned questionnaires were discarded on the grounds of classroom observation and providing answers that out of criteria (i.e., because of distrusting responses and inconsistent). Which means that during data validation one participant was rated up-from 1 to 5 the five level Likert scale responses and when finished rating in such way that started rating down from 5 to 1 constantly until finished the administered survey questions. Two participants were rated 5 constantly the five level Likert scale responses for all of the administered survey questions. The fourth participant provided a response by setting additional criteria and rating on 6 that fall in the upper outlier.

First objective: To determine the level of awareness, perceptions, attitudes, and practices (implementation) of 21st-CS in chemistry education (grades 9 and 10), six series of Likert-type questions each for the first three domains (awareness, perceptions, attitudes) and five for the last domain (practices of 21st-CS) were administered to chemistry teachers and students. The responses obtained were presented in Table 2 and 3, respectively.

Table 2: Teachers level of awareness, perceptions, attitudes, and implementation of 21st century skills

Indicators of teacher's awareness about implementation of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication).	n	M	SD	Level
1. I am familiar with the terminology 21st-CS.	73	2.75	1.038	Moderate
2. Planning is necessary to integrate 21st-CS with chemistry content.	73	2.86	0.990	Moderate
3. Sufficient technological pedagogical content knowledge is needed to practice 21st-CS with chemistry lesson.	73	3.19	0.991	Moderate
4. Use of teaching methods (e.g., discussion, flipped classroom, inquire-, project-, problem-based learning, thinking-based learning) foster implementation of 21st-CS.	73	3.07	0.918	Moderate
5. Students' learning of 21st-CS can be assessed using different assessment method (e.g., group work, project work, assignment).	73	3.25	0.894	Moderate
6. Students' learning of 21st CS can be assessed using different assessment tools (e.g., presentation, self-assessment, peer-assessment, rubrics, performance assessment).	73	3.16	0.850	Moderate
Awareness	**73**	**3.09**	**0.855**	Moderate
Indicators of teacher's perceptions towards implementation of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication).	n	M	SD	Level
7. The teaching-learning process in the digital age similar to industrial age.	73	3.97	1.142	High
8. Integrating 21st-CS with chemistry education affects the content to be covered.	73	3.63	1.369	High
9. It is beyond the context of our country to integrate 21st-CS with chemistry content.	73	3.93	1.262	High

10. Teacher is a facilitator (coacher, guider or co-learner) learning in the 21st century.	73	3.67	1.395	High
11. It is difficulty for both teacher and students to integrate 21st-CS with chemistry content.	73	3.79	1.394	High
12. One shot test (mid-exam and or final exam) cannot assess students' development of 21st-CS.	73	4.23	1.048	High
Perceptions	**73**	**4.01**	**1.037**	**High**
Indicators of teacher's attitudes towards implementation of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication).	n	M	SD	Level
13. Tailored instruction is important to integrate 21st-CS with chemistry content, since it meet the individual need of learners.	73	3.88	1.343	High
14. Allowing students to work together to achieve a common goal foster the implementation of collaboration skills with chemistry lessons.	73	4.08	1.199	High
15. Use of a multiple teaching methods help to implement 21st-CS in chemistry lesson.	73	4.07	1.084	High
16. Integrating of 21st-CS with chemistry content is desirable in the digital age.	73	4.04	1.059	High
17. Integrating of 21st-CS with chemistry education avoid students' surface learning of chemistry concepts.	73	4.04	1.086	High
18. Use of a variety of assessment tools (e.g. rubrics, observation checklists) help teacher to guide student development of 21st-CS.	73	4.03	1.154	High
Attitudes	**73**	**4.09**	**1.050**	**High**
Indicators of teacher's implementation of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication) during chemistry lesson.	n	M	SD	Level
19. The chemistry lesson delivered in line with the student's individual learning style.	73	2.63	1.458	Moderate
20. Chemistry teacher motivate students to learn the chemistry concept deeply integration with 21st-CS.	73	2.53	1.248	Moderate
21. Students get opportunities to search, create and share information associated with chemistry concepts with others students.	73	2.78	1.484	Moderate
22. During chemistry lesson student-centered approach is used to foster 21st-CS.	73	2.77	1.264	Moderate
23. During chemistry lesson student relate the chemistry concepts with their daily life experiences to develop their higher-order thinking skills.	73	2.88	1.353	Moderate
Implementation of 21st-CS	**73**	**2.70**	**1.126**	**Moderate**

Note: M = Mean, n = Sample, SD = Standard deviation. The Levels of the Mean Scores on 5-point Likert Scale:

< 1.50 = Very low, 1.50 - 2.49 = Low, 2.50 - 3.49 = Moderate, 3.50 - 4.49 = High, 4.50 – 5.00= Very high [28].

Table 3: Students level of awareness, perceptions, attitudes and practice of learning 21st century skill

Indicators of student's awareness about practices of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication).	n	M	SD	Level
1. I am familiar with the terminology 21st-CS.	382	2.55	1.141	Moderate
2. Planning is necessary to integrate 21st CS with chemistry content.	382	2.65	1.142	Moderate
3. Sufficient technological pedagogical content knowledge is needed to practice 21st-CS with chemistry lesson.	382	2.63	1.156	Moderate
4. Use of teaching methods (e.g., discussion, flipped classroom, inquire-, project-, problem- based learning, thinking-based learning) foster the implementation of 21st-CS.	382	2.85	1.145	Moderate
5. Students' learning of 21st-CS can be assessed using different assessment methods (e.g., group work, project work, assignment).	382	3.07	1.064	Moderate
6. Students' learning of 21st-CS can be assessed using different assessment tools (e.g., presentation, self-assessment, peer-assessment, rubrics, performance assessment).	382	3.06	1.052	Moderate
Awareness	**382**	**2.91**	**1.014**	**Moderate**
Indicators of student's perceptions towards practices of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication).	n	M	SD	Level
7. The teaching-learning process in the digital age similar to industrial age.	382	4.14	1.217	High
8. Integrating 21st CS with chemistry education affects the content to be covered.	382	3.52	1.452	High
9. It is beyond the context of our country to integrate 21st-CS with chemistry content.	382	3.68	1.354	High
10. Teacher is a facilitator (coacher, guider or co-learner) learning in the 21st century.	382	3.71	1.499	High
11. It is difficulty for both teacher and students to integrate 21st-CS with chemistry content.	382	3.63	1.443	High
12. One shot test (mid-exam and or final exam) cannot assess students' development of 21st-CS.	382	3.57	1.477	High
Perceptions	**382**	**3.91**	**1.104**	**High**

Indicators of student's attitudes towards practices of 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication).	n	M	SD	Level
13. Tailored instruction is important to integrate 21st-CS with chemistry content, since it meet the individual need of learners.	382	3.75	1.373	High
14. Allowing students to work together to achieve a common goal foster the implementation of collaboration skills with chemistry lessons.	382	3.90	1.191	High
15. Use of a multiple teaching methods help to implement 21st-CS in chemistry lesson.	382	3.89	1.225	High
16. Integrating of 21st-CS with chemistry content is desirable in the digital age.	382	3.95	1.183	High
17. Integrating of 21st-CS with chemistry education avoid students' surface learning of chemistry concepts.	382	3.95	1.178	High
18. Use of a variety of assessment tools (e.g. rubrics, observation checklists) help teacher to guide student development of 21st-CS.	382	3.96	1.163	High
Attitudes	**382**	**3.99**	**0.978**	**High**
Indicators of student's practices of learning 21st-CS (e.g., creativity, critical thinking, problem solving, collaboration, communication) during chemistry lesson.	n	M	SD	Level
19. The chemistry lesson delivered in line with the student's individual learning style.	382	2.97	1.432	Moderate
20. Chemistry teacher motivate students to learn the chemistry concept deeply integration with 21st-CS.	382	3.11	1.409	Moderate
21. Students get opportunities to search, create and share information associated with chemistry concepts with others students.	382	3.15	1.482	Moderate
22. During chemistry lesson student-centered approach is used to foster 21st-CS.	382	3.46	1.366	Moderate
23. During chemistry lesson student are encouraged to relate the chemistry concepts with their daily life experiences to develop their higher-order thinking skills.	382	3.67	1.330	High
Practice of 21st-CS	**382**	**3.27**	**1.244**	**Moderate**

Note: M = Mean, n = Sample, SD = Standard deviation. The Levels of the Mean Scores on 5-point Likert Scale: < 1.50 = Very low, 1.50 - 2.50 = Low, 2.50 - 3.50 = Moderate, 3.50 - 4.50 = High, 4.50 – 5.00= Very high [28].

Authors [29], explained how researchers can create a Likert scale to measure a specific attribute. . A composite score (sum or mean) is calculated from a series of Likert-type items. To In such a way that the composite score of Likert scales has to be analyzed at the interval measurement scale. For interval measurement scales, descriptive statistics such as means (Ms) and standard deviations (SDs) are recommended.

According to Wanjohi and Syokau [30], the Likert scale decision rule, a neutral attitude is implied by a mean score of 3, a negative attitude is indicated by a mean score below 3, and a positive attitude is denoted by a mean score above 3. The mean scores on the Likert scale span from 1.0 to 2.49 (negative), 2.5 to 3.49 (neutral), and 3.5 to 5.0 (positive).

Table 2 and 3 show that the awareness levels of chemistry teachers’ and students’ (n = 73, M = 3.09, SD = 0.855, and n = 382, M = 2.91, SD = 1.014, respectively) regarding 21st-CS practices in chemistry education were moderate. The teachers' and students' perceptions towards 21st-CS practices were generally favorable and rated high (n = 73, M = 4.01, SD = 1.037, and n = 382, M = 3.91, SD = 1.104, respectively), also attitudes rated high and positive (n = 73, M = 4.09, SD = 1.05, and n = 382, M = 3.99, SD = 0.978, respectively) towards practices of 21st-CS.

Second objective: An independent sample of the Jonckheere-Terpstra Test was used to identify the differences in awareness, perception, attitude, and practice of 21st-CS in chemistry education. The data in Table 4 illustrate the results.

Table 4: Significant differences across awareness, perceptions, and attitudes of chemistry teachers and students in practices of 21st-CS in chemistry education

Jonckheere-Terpstra Test[a]						
	Students Practices of 21st-CS by Perception	Teachers implement of 21st-CS by Perception	Students Practices of 21st-CS by Attitude	Teachers implement 21st-CS by Attitude	Students Practices of 21st-CS by Awareness	Teachers implement of 21st CS by Awareness
Number of levels	5	5	5	5	4	4
N	382	73	382	73	382	73
Observed J-T Statistic	27779.500	907.500	24103.500	908.000	24827.500	691.000
Mean J-T Statistic	26950.500	990.500	24337.500	898.500	24540.500	848.500
Std. Deviation of J-T Statistic	1159.900	97.320	1120.165	94.457	1131.464	92.256
Std. J-T Statistic (Z)	.715	-.853	-.209	.101	.254	-1.707
Asymp. Sig. (2-tailed)	.475	.394	.835	.920	.800	.088
a. Grouping Variable: Perceptions, Attitudes, Awareness.						

The researchers assumed that in order to influence practices (implementation) of 21st- CS in chemistry education: Medians Awareness ≥ Medians Attitude ≥ Medians Perception and the level of awareness, perception and attitude of students towards practices of 21st- CS is less than or equal to chemistry teachers. Table 4 reveals that there was no significant difference in the way students perceive and practice of 21st-CS (TJ-T = 848.500, Z = -1.707, p =.457). By perception, there was no significant difference in practices of 21st-CS by chemistry teachers' (TJ-T = 990.500, Z = -.853, p =.394). By attitudes, students' practices of 21st-CS show no significant difference (TJ-T = 898.500, Z = -.209, p =.835). There was no significant difference between teachers' attitudes and practices of 21st-CS (TJ-T = 898.500, Z =.101, p =.920). The awareness of students' and practices of 21st-CS shows no significant difference (TJ-T = 24540.500, Z =.254, p =.800). A non-significant difference exists between teachers' awareness and practices of 21st-CS (T_{J-T} = 990.500, Z = -.853, p = .088).

Third objective: To identify the relationship of awareness, perceptions, attitudes and practices of 21st-CS among 455 participants Kendall's tau-b (τ_b) correlation analysis was used. The results obtained presented in Table 5. The findings showed a statistically significant, weak positive correlation (τb = .194, p < .001) between awareness and perceptions, a weak positive correlation (τb = .169, p < .001) between awareness and attitudes (since .001 < .005). Awareness and practices of 21st-CS showed no significant correlation (τb = .00, p = .992). Perceptions and attitudes showed a weak positive correlation (r = .295, p < .001). It was statistically not significant, a weak positive correlation (τb = .019, p = .015) between perceptions and practices of 21st-CS. Attitudes and practices of 21st-CS exhibited statistically not significant, a weak negative correlation (τb = -.004, p = .916).

Table 5: Kendall's tau_b association of awareness, perceptions, and attitudes of chemistry

teachers and students towards practices of 21st-CS in chemistry education

		Awareness	Perceptions	Attitudes	Practices of 21st-CS
Awareness	Correlation Coefficient	1.000			
	Sig. (2-tailed)	.			
Perceptions	Correlation Coefficient	.194**	1.000		
	Sig. (2-tailed)	< .001	.		
Attitudes	Correlation Coefficient	.169**	.295**	1.000	
	Sig. (2-tailed)	< .001	< .001	.	
Practices of 21st CS	Correlation Coefficient	.000	.019	-.004	1.000
	Sig. (2-tailed)	.992	.615	.916	.
	N in all cases	455	455	455	455

**. Correlation is significant at the 0.01 level (2-tailed).

5. Discussion

Practices of 21st-CS in chemistry education had an average awareness level, as indicated by an overall mean, for both teachers and students. This in turns there was an attempt of practicing (implementing) of 21st-CS in chemistry education in the chosen SSs of Addis Ababa City Administration. However, what the descriptive statistics data revealed and the results of qualitative data gathered through classroom observation, FGD, interviews, and secondary data sources were incongruent. The results of FGD and interviews indicated that most of the teachers and students did not familiar with the terminology of 21st-CS. During FGD and interviews most of the participants were simply verbalized the use of digital technology in the 21st-century but they did not raise any domains of 21st-CS.This suggested that students and teachers were not aware of 21st-CS. Because in 2021 in the new curriculum KG-12 under Programme 3 component two objective stated as "21st century higher-order skills such as critical thinking, creativity, scientific temperament, communication,collaboration/teamwork, multilingualism, reasoning, problem solving, ethics, social responsibility, and digital literacy will be developed in learners from all sectorism" [7, p.62]. In addition, in 2009 in the revised curriculum framework from KG- 12 creative thinkers, problem solvers, active innovators, IT literate, informed decision makers, democratic and tolerant were introduced Reference [31]. This revealed that the domain of 21st-CS were introduced in Ethiopian curriculum a decade and half ago but the teaching and learning system still the whole classroom instruction, what the student know and how do it still not get attention. This in indicates that during curriculum development some domains of 21st-CS were introduced but in the implementation stage kept aside. This shows no proper attention was given how the designed curriculum was implemented. Because there was a statement "Develop and implement a competency-based general education curriculum from pre-primary to Grade 12" stated by [7]. It is impractical to learn competency-based using direct instruction.

Therefore, simply introducing of the presently demanding issue in a curriculum nothing do for students building of 21st-CS except showing a superficial curriculum without accompanying with appropriate teaching-learning system of education 4.0. If it was introduced into the curriculum must be implemented by proper attention and follow up accompanying with skills gap (providing training) for all education actors.

Regarding to the new curriculum during the interview, teachers informed that training was given in September 2023 on the contents included in the new curriculum of SSs and preparation of daily lesson plan…, but no information was obtained during the training on how to teach and assess 21st- CS. "Our chemistry teacher used talk and chalk only rather than encouraging us to learn through creative and critical thinking, collaboration, and communication," the students said during FGD. Failing to adapt to education 4.0 could hinder to cultivate high-skilled workforces for digital workplaces in the knowledge-based economy era. The 21st-CS integration with chemistry education should no longer be assumed as teachers' were professional expertise (know how to teach, and assess 21st-CS). Since the 21st-CS (e.g., creative and critical thinking, creativity, problem solving, collaboration, complex communication) require a more intricate understanding than content knowledge from teachers and students. Therefore, professional development (PD) should be an important part of the 21st century learning programme. From a six components of framework of 21st century learning skills, PD is one of the components according to partnership for 21st century learning skills [32]. Because its priority in education is new, due to the demand of high-skilled workforces in new economy order [2]. Since the new world economic order need individual and collective to have 21st-CS to succeed. To address the skill and knowledge gap observed in the teaching-learning process concerning the new demand in education, teachers should get opportunities to grasp how to teach, select effective teaching strategies, chose appropriate assessment methods and tools, and how to assist students in practicing of 21st-CS. This help teachers to use of effective teaching methods (e.g. project based learning, inquire based learning) to participate students in learning. When students fully involved in learning deeply understand chemistry concepts and build 21st CS (e.g., problem-solving, critical thinking, collaboration and others). It also help teachers' to identify students' strengths (their learning styles or intelligences). In line to this Erdem [1], recommended that pre-service or in-service teacher training programmes must provide training with respect to 21st CS to equipped teachers with these skills be able to teach students as intended. Thus, PD should continual provided for teachers regarding education 4.0.From fifteen selected SSs, 60 chemistry teachers were observed; the majority of them used pure lecture in 45 minutes (i.e., a teacher-centered approach was predominated). In accordance with this, students were required to sit facing towards the chalkboard for 45 minutes (salient listeners). Students were sitting in a ratio of 1:3 on tables that were fixed with its seats that hinder students to form flexible groups based on their learning preferences. Some teachers were more worry for supervision, because of that they carry additional documents (e.g., student attendance form, form of discussion with parents, tutorial class report form, mark list, annual plan) while entering the classroom rather arranging and using teaching aids. For example, the peer observation format asked student sitting arrangement, notebook, different documents related to students, portion covered, use of blackboard, hand writing of the teacher, teaching method, use of teaching aid, giving a brief note, medium of instruction. Through classroom observation the researchers were recognized that the peer observation was conducted to seek for reporting but not to learn, exchange of knowledge and skills because of the following facts.

1. They considered pure lecture as active teaching method, as a result the majority of teachers were frequently used.

2. The students sitting arrangement always parallel line facing toward chalkboard (neglecting individual learning styles).

3. In their daily lesson plan some said no need of teach aid, some left vacant space and some stated textbook and chalk. This means neglecting the concept of chemistry is experimental science, students understand chemistry through "learning by doing" approach. This can clarified using the asymptotic assumption of approaching the line but never touch. Conversely, teaching of chemistry neglecting "learning by doing" approach shows absent from cultivating creative thinkers, innovators, problem solvers, negotiators, effective communicators, etc. but fostering rote memorization ability that unfit the need of digital era.

4. Most of teachers were used their native languages (mother tongue) during instruction. The curriculum was prepared by English considering that English is a medium of instruction. But the actual medium of instruction in the classroom after 10 minutes the lesson introduced instruction was shifted to either Amharic or Afaan oromoo based on students and teachers background. The researchers were strongly argue that effective communication should be made with as the curriculum ordered. Because assessments, tests, examination were prepared in English in line to the textbook. This may be one of the challenges that students face difficulty unable to read chemistry textbook. Both the teacher's evaluation and peer observation format must revised in line to education 4.0 or learning in the 21st century rather simply wasting of time with irreverent routine tasks that did not contribute any significant role for students development of 21^{st}-CS.

In a class a minimum 17 and maximum 77 students (see Figure 1). However, the way chemistry lessons delivered were pure lecture in reduced class size as well as in large class size. The availability and utilization of instructional materials including students sitting arrangement were the same. This suggested that increase or decrease of number of students in a class had not brought any change in the teaching of chemistry contents as well as 21st-CS. In line to this, Rotherham and Willinghan [33], reported that teachers rarely use 21st-CS, since most of the instructional time is composed of seatwork and whole class instruction led by the teacher. Even when class sizes were reduced, teachers did not change their teaching strategies or use. This formed that teachers as well as students did not know about learning in the 21st century. They proceed their teaching and learning as familiarized before. Another justification there were an average of 47 to 48 students (see Figure 1) in a classroom those have different learning styles.

Figure 1: Students' simply listening lectures

Nevertheless, chemistry lessons were delivered through direct instruction (i.e., unique individual learning preferences were not taken into account) in all chosen SSs, except in some classrooms think pair share and group discussion were used. Even if, the pairs and group discussion used were not effective to practice 21st-CS (see Figure 2). Since both teachers and students did as usual for content knowledge learning. This revealed that students were obscured from learning according to their strength of learning (application of theory of MI or learning styles was disregarded to promote integration of 21st-CS with a chemistry lessons).

Even to teach 21st-CS, the teachers' daily lesson plans were inadequately prepared for the subject matter. The important components of the lesson plan, such as time, teacher and student activities, and teaching and assessment methods were stated haphazardly. The time allocation illustrates the teacher's role during the 45 minutes in a class. As an illustration, the action verb "know" in the daily lesson plan denotes content knowledge but does not specify how students perform (see Table 6). Based on authors [34] suggestion, teachers must know evidence (what students do, say, make, or write) rather than inference (what students know, understand, think, or feel).

Table 6: The observed daily lesson plan of grade 10 chemistry unit two

Topic of the lesson: Solutions.					
Rational of the topic: "Clearly understand the difference between suspensions and solutions."					
Competency of the lesson: "At the end of this lesson student will be to know solutions."					
Stage	Time	Teacher's activities	Student's activities	Teaching methods	Assessment methods
Starter activities	10´	"Revise the previous lesson by brainstorm"	"Following"	"Gap-lectured"	"Asking oral question"
Main activities	25´	"Providing short note"	"Taking note"	"Gap-lectured"	"Asking oral question"
Concluding activities	10´	"Organize suspensions and solutions tasks"	" Doing tasks"	"Gap-lectured"	---
Teaching aids : "No need, book teaching aid"					
Teaching materials: "Text book, Reference book"					

According to Mishra and Koehler [35], the Technological Pedagogical Content Knowledge (TPACK) framework focused on integration of three knowledge, namely content (subject matter knowledge), pedagogy (how to teach), and technology (knowledge of how to use technological tools) in teaching and learning. The framework build teachers understanding of content and skills needed that help to choose, utilize and incorporate technology effectively and effectively in delivering the lesson. For example, chemistry teacher's faces difficulties to explain and demonstrate substances in microscopic level and also students are confronted with challenges to understand conceptually. If multimedia tools, which integrate the animation of molecular models students get opportunities to visualize chemical processes at the sub-microscopic level that help them to understand the three-dimensional structures [36]. Also researchers' suggested that ICT can provide solutions to various challenges those affect the teaching-learning process of chemistry education to improve its quality [37]. This provides opportunity for students to deeply understanding the chemistry content knowledge and mastery of skills. Moreover, use of technology in teaching and learning help to development of 21st CS [38]. In another hand, the teaching and learning approaches in the 21st century must befit the needs of digital natives. Because the learning characteristic of digital natives (experienced Internet users) is different from the digital immigrants (less-experienced Internet users). Digital natives prefer to receive information quickly; parallel process information; learn from pictures and video rather than text; have random access to information, such as a hyperlink style web page allows; interact with others while learning [39]. However, in the selected government SSs of study area the use of technology following of TPACK framework had not get attention. In some classroom Plasma TVs (formerly used for education purposed broadcasting from South Africa) and LCD that working with USD card simply stand currently without giving any function. This negatively affect the implementation as well as students building of 21st-CS during their schooling. This also indicates that the mismatch of Minister of Education stated and actually exist in the schools compound. For effective learning access of sufficient materials such as DVDs, radio, and digital content for teachers and students is a precondition in all schools, according to [7].

Chemistry teachers were asked to share with the researchers their methods of instruction to implement 21st-CS in the classroom. Most of them undoubtedly relied on the justification that the teacher-centered method was used during instruction because of different factors. The investigators also confirmed through classroom observation, the majority of chemistry teachers of the selected SSs were focused on transferring of knowledge to the learners through whole class instruction. Teachers had no time to assess how the students understand the theoretical concept and transfer into another context. Because they were busy in giving a note and explaining the lesson. The chance of students were simply absorbing what their teacher preaching to them, no time to associate the theoretical concepts with their daily life experiences and real world to reach on Aha stage. Similar research findings were reported on the traditional model of learning in which 21st-CS included in the curriculum. Students learn the abstract concepts of chemistry with talk and chalk methods, learning by doing was neglected, and SSs students learn chemistry contrary to learning of 21st- CS [10]. Saavedra and Opfer [40] argued that the dominant teaching model in schools is still the transmission model, and it is not possible to teach 21st-CS through this model. This suggested that the currently in use teaching methods in the selected government SSs of study area were not effective to implement as well as to develop 21st-CS in line to the global demand.

The majority of teachers were not interested to use the identified effective teaching methods or create his/her own participatory teaching strategies that involves students in learning. They were finished the allowed time with talk and chalk. Some teachers were worry about the report of class missing (i.e., to avoid a report of period missing) rather than how I teach my students effectively and efficiently. Some of them were in harry to cover the chemistry textbook. They entered the class, and then with speedy talk and chalk continue explanation of the explicitly concept of the chemistry to the learners. The instruction continue in such away at every session without considering what must students know, how they know it and apply the concept they understand (see Figure 2). Which means that instruction was not aligned with a constructivist learning approach. As a result, some students were slept on their tables while the chemistry lesson was delivered through a traditional mode of instruction (see Figure 2).

Figure 2: Talk and chalk method of teaching

The data were collected from teacher's evaluation format to assess:

1) Why they run to complete portion rather than focusing on who students know and do it?

2) Why they enter simply to the class without arranging students for learning?

From the teacher's evaluation format three points directly addressed this two reasons. (1) Teachers were evaluated based on students achievement result. The criteria showed that students must score greater than 50 should be

100%, from 75 to 85 should be 25% and from 86 to 100 should be 15%. The teachers were strongly focused on recalling or memorization of facts that used only lowered thinking skills to achieve the evaluation criteria. As a result, they did not worry about how students know and do to achieve the targeted results. What the teacher's evaluation format concerning achievement result required (Addis Ababa City Education Bureau) not aligned with the Ministry of Education was planned. According to Ethiopian Ministry of Education [6], students not learn to recall what they have learned in class but to apply these concepts or how to do something. (2) Teachers were evaluated based on avoiding miss of class and not less use of the allotted time. This recognized that some teachers were simply enter into the classroom and finished their time with talk to show their availability in the school compound rather than let do my best as much as possible to address students learning of 21st-CS. (3) Teachers were evaluated based on portion coverage. This also contradicting what MoE [6] was stated. Because completing portion and knowing how to do something/applying the concept taught did not required equivalent time. First students must understand the concept (hard skill) and then transfer what they understand to another context (soft skill). In line to this, Bell and his colleagues. [41] suggested that emphasis not on numbers of teaches units students accomplished but on what students can do with the knowledge acquired. This indicated that there was lack of giving proper attention and awareness about how students learn education 4.0. This mismatch of the intended objectives of learning in the 21st century and actually going on the classroom in the spirit of earlier education negatively affected the students building of 21st-CS. Because learners did not get opportunities to practice 21st-CS at the time of their schooling age at the grades 9 and 10. Consequently, this will be negatively affect their career and life in the digital age.

Assessment is one of the educational component used to verify students learning of certain content knowledge and skills through collecting, analyzing and interpreting information to provide feedback and judge. Assessment have three constituents, namely a task (what the students elicit), a response format (what to be seized or detected), and a scoring system (telling performance with a word, also with a numeric value) (Ruiz-Primo & Shavelson, 1996 cited in [42]. According to Care and Kim [43], defining and describing skills, tools formats, its function, and scoring mechanism are important to understand and validate assessment outcomes of 21st-CS. In the 21st century learning chemistry focus on "learn by doing". Firman [44] suggested that the evidence of how know chemistry concept and learn 21st-CS can be revealed through assessment methods used, such as discussion, doing work, project work, presentation. The assessment method used can be reflected through different assessment tools such as presentation, self-assessment, peer-assessment, observation checklist, rubrics, performance based assessment, student response systems and so on. Presentation is the formal talk, action, a performance, exhibition, or demonstration that made in front of the whole class or on-line by students using verbal, short note, graphs, diagrams, PowerPoint, prototypes or other visual aids. Self-assessment is an assessment that helps students to identify their own strengths and weakness and make self-adjustment to meet the specified criteria. Peer assessment is a formative assessment used to assessment worth of other students' work (papers, project works, presentations or other skilled behaviors), and to give and receive feedback. Observation checklist consists a list of performance criteria related with specific performance activities that the presence, absence or the response given to the specified character/ behavior can be checked. Rubrics are consisting of criteria that guide students and teachers which work will be judged and point values associated with these criteria. Performance based assessment, also known as project-based or authentic assessments that allows teachers to assess what students know about a topic and how to apply that knowledge in a “real-world” situation. Student response system it comprises different technology-based formative assessment tools in which students answered rapidly, and the teacher can display their response immediately by keeping namelessly. The assessment methods used in the chosen SSs were school based assessment such as oral questions, classwork, homework, group works, assignments, worksheets, test, exams, and lab reports. These assessment methods mainly focused on assessing the chemistry knowledge students acquired, the skills students developed integration with the construction of knowledge were out of teachers and students mind. Their target of teaching and learning were simply delivering the knowledge and grasping chemistry theoretical concepts, respectively.

The tool format used to assess 21st-CS will not focus on a student's ability to memorize or recall information that led to knowledge of the correct response. The traditional assessments did not give an opportunity to learn by trial and error. The assessment must be unfamiliar with prior knowledge. Therefore, instead of simple and mechanistic cause-effect assumptions (i.e., stimulus-response associations or input-output relations), a more holistic kind of systems thinking is required to consider the dynamics of the relevant processes and the feedback [36]. This can be illustrated using Bloom’s taxonomy. According to Anderson and Krathwohl [45], the revised Bloom’s taxonomy has the cognitive dimension (remember, understand, apply, analyze, evaluate and create) and the knowledge dimension (factual, conceptual, procedural and metacognitive). Ruiz-Primo [40] explained five types of knowledge and identified four knowledge for assessment determinations. (1) Declarative knowledge (knowing that), (2) procedural knowledge (knowing how), (3) Schematic knowledge (knowing why), (4) Strategic knowledge or (knowing when, where, and how knowledge applies), and metacognitive knowledge (knowing about one’s cognition*)*.

Declarative knowledge involves basic elements students must know in specific subject matter or to solve problem within. This type of focuses on knowledge definitions of terminology, describing of facts, specific details or specific elements to classify, and categorize. Schematic knowledge comprises more structured forms of knowledge either explicit or implicit. It consist of mental pictures, schemas, or concepts that are used to organize information in an interrelated and methodical way. This knowledge help students to apply principles or clarifying patterns to come up a problem (investigating) and procedural knowledge. It involves classification, categories, principles, generalization theories, models [45]. Procedural knowledge involves how to perform something, means of inquiry, criteria to use skills, algorithms, techniques, and methods. It the principle of if-then (application rules, sequence of steps or procedure to arrive at the final outcome). For example, measuring pH of a solution using pH mater, applying algebraic method (an algorithm) to balance chemical equations, determining significant figures by using rule of addition, subtraction, multiplication, and division. Strategic knowledge refers to forecasting, monitoring, crossing the problem, investigating, and coordinating other kinds of knowledge. Strategic knowledge characterized by ill-defined problems. It involves breaking down of task into subtasks, reacting to the process to search other solutions, recognizing where to use a specific bit of schematic knowledge, or assimilating the three former kinds of knowledge in an effective way [42].Based on aforementioned concepts, Table 7 shows school based assessment did not capture any of the 21st -CS.

Table 7: Sample of school based assessment

Sample of school based assessment	Type of assessment	Interpretation
The rate of dissolutions largely depend on A) Interparticle force C) Pressure B) Temperature D) Surface area	Worksheet	To answer this item students retrieve information (remember) and know specific details of rate of dissolution (declarative knowledge). It does not indicating 21st -CS.
How many moles of O_2 gases are needed to produce 9.76 mol of C_3H_8?		It does not capture 21st -CS. Student simply apply the formula (apply) and use of algorithm to answer (Procedural knowledge).
Describe the three step of solution process.		To answer this item students retrieve information (remember) and knowing specific elements of step of solution process (declarative knowledge). It does not focusing 21st -CS.
The sum of 35.05 + 6.1 with the correct significant figure A) 41.25 C) 41.2 B) 41.15 D) 42	Test	It does not address 21st -CS. To answer this item students remember addition rule (remember) and identify criteria for judgment (Procedural knowledge).
Closeness of the measured value to true value is A) Accuracy C) Precision B) Correction D) Uncertainty		To answer this item students retrieve information (remember) and know definition of terminology (declarative knowledge). It does not targeting 21st -CS.
Write at least three (3) common drugs chemistry that provided.		It does not capture 21st -CS. To answer this item students remember information (remember) and state specific elements (declarative knowledge).
Suppose an object has mass of 30 g and has density of $2g/cm^3$ then the volume is A)15 cm^3 B) 60 cm^3 C) 25 cm^3 D) 12.5 cm^3	Mid exam	Student simply apply the formula (apply) and use algorithm to answer (Procedural knowledge). It does not targeting 21st -CS.
What can be said about reducing agents in redox reaction? A) It decrease oxidation number B) It reduced C) It loses electron D) It gains electrons		To answer this item students retrieve information (remember) and know specific details of reducing agents (declarative knowledge). It does not capture 21st -CS.
Calculate the percentage composition by mass of $CaCO_3$?		Student simply apply the formula (apply) and use algorithm to answer (Procedural knowledge). It does not indicating 21st -CS.
Taking the significant figures into		It does not capture 21st -CS. To answer this item

consideration, the product of 109.832, and 0.6107 should be written as A) 67.0744 B) 67.1 C) 67.07 D) None of the above	Final exam	students remember multiplication rule (remember) and identify criteria for judgment (Procedural knowledge).
What was determined from Robert Millikan's oil drop except? A) mass of electron C) charge of electron B) charge to mass of electron D) mass of proton		To answer this item students retrieve information (remember) and know specific details of Millikan's oil drop experiment (declarative knowledge). It does not capture 21st -CS.
Solubility of a substance in a given solvent depend on ___________, ___________, ____________		It does not targeting 21st -CS. To answer this item students remember information (remember) and state specific elements (declarative knowledge).

The result of Table 7 revealed that the school based assessment not yet embraced any of the 21st -CS. The assessment methods used in the SSs of the study area had not aligned to learning in the 21st century. Because students were asked to answer specific chemistry concept by applying procedures or identifying facts and concepts without using more thinking skills. It means that the divergent thinking and convergent thinking were not designed properly to enhance students learning of 21st-CS. In general, the secondary data sources collected on assessment tools such as tests, examinations, assignments, worksheets, table of specification, and mark list reporting formats were jam-packed with content knowledge or lower-order thinking skills. The table of specifications confirmed that proper attention and awareness had not given to implementation of 21st-CS in chemistry education. Because as shown in Table 7 the test blue print filled with the lower-order thinking (remembering, understanding, and application). Mark list reporting formats also support the evidence of test blue print. In the mark list report format, 60% were completed in the classroom as continuous assessment (test, quiz, class activity or participation, assignment, project, exercise book, mid-exam 20 to 25% paper and pencil test, final exam 40% paper and pencil test). The time allocation for tests or examinations were 40 minutes to 1:30 hours for 10 to 38 items. In speed test it is difficult to measure 21st-CS. Regarding to this, [46] stated that in a speed-based test, students have no more chance to apply the skills they acquired; it only measures what students can do at a specified time. In the reporting format, practical assessment, specific activities that assess students' learning of 21st-CS, technology-based assessments were neglected. On another hand, MoE [7] informed that the assessment system from regional to national level revised in order to assess skills as well as higher order cognitive skills and establishing technology assessment system. This informed that students were lacked more chance to practice and prepared for the next schooling, career, and future life. Consequently, they will be challenged to succeed in the knowledge-based economy era due to the discrepancy of the planned and implemented curriculum.

An overall mean value of perceptions were high, indicating a favorability of situation to implement 21st- CS in chemistry education. However, some indicators such as the teaching-learning process in the digital age similar to the industrial age, integrating 21st- CS with chemistry education affects the content to be covered and it is beyond the context of our country to integrate 21st- CS with chemistry shows invalid perceptions in the context of learning in the 21st century. High perceptions of these indicators reflect negative practices of 21st-CS during chemistry lessons. Because education in the digital age differs greatly from that of the industrial age. While the development of factual and procedural knowledge was the primary goal of education in the industrial society, the development of conceptual and metacognitive knowledge is more important in the information or knowledge society [47]. In education 4.0, learning is student-centered, link to the student, demonstrate by the student and accomplished by the student [48]. Concerning teachers role in the 21st century learning, authors [40] stated that teachers are not imparting knowledge to the learners but facilitate, assist, assess, coach, guide, or co-learner. This suggested that 21st- CS cannot be taught using the whole class instruction method. Rarely, in pairs, students share ideas, while smaller groups form with students sitting behind them (see Figure 3).

Figure 3: In rare case students share ideas in pairs and forming small group with students sitting behind

Rarely, students reflect their understanding to the whole class through oral communication or using the blackboard, however, their teacher merely observes in standing in the middle or corner instead of guide or assisting students learning of 21st-CS. The students' pairs and group discussion, and oral communication were not suitable to implement 21st-CS, because both teachers and students did as usual for content knowledge learning. Basically, integrating 21st-CS with subject matter or interdisciplinary learning is a global issue, not a mandatory of some countries, because the world economy needs 21st-CS in every walk of life. Koenig cited in [49] stated that contemporary workplaces need workforces who can solve non-routine problems, perform complex communication, and have social skills. In chemistry learning therefore, student must at center of learning, teacher should play facilitation role (shifting away from spoonful feeding) and give equal emphasis for both soft skills and chemistry knowledge to enable students in knowledge-led economy era.

An overall mean value of attitudes were high, showed a positive impact on practices of 21st-CS in chemistry education, but the average score of participants indicated moderate practices of 21st-CS. Nonetheless, the descriptive statistics results were not substantiated by the evidence collected through classroom observation. Twenty-first century skills favor student-centered method that accompanied by appropriate pedagogies (teaching methods) such as problem- and project-based learning that provide opportunities for students to collaborate, work on authentic problems and engage with the community [39]. This shows pure lecture method is invalid to teach 21st-CS integration with content knowledge. Saavedra and Opfer [40] suggested that it is impossible to teach 21st-CS through the traditional mode of instruction. This approach predominately observed in teaching of chemistry in the government SSs of Addis Ababa City Administration. As Piaget stated that children are individuals who persistently create knowledge and confirm their senses of the world [50]. This implies students are active participate not passive listener. In constructivist classroom students are actively take part in the process of learning and teacher act as facilitator, coach, guider, mediate, prompt, assister, provoker, co-explore and assessors to develop and understanding students learning. Such techniques provide opportunities for students to engage in critical and creative thinking, analysis, and synthesis of ideas and motivate students to search, challenge, and formulate their own thinking, views, and conclusions [11]. To sum up, teachers should use student-centered method to implement 21st-CS during chemistry lessons. This help students to understand the concept deeply (no more surface learning) and develop 21st-CS.

The majority of teachers were negative attitude towards collaboration. The collaborative learning model that the Ethiopian People's Revolutionary Democratic Front (EPRDF) regime (1991–2017) introduced have negative connotation. The drawbacks of collaborative learning stem from the fact that more credit was given to its political advantage rather educational benefits. The collaboration skills introduced in Ethiopian schools by the name "የትምህርት ሰራዊት," which means "Educational Army" in Amharic. When collaborative learning was introduced in education sectors, teachers and students were grouped in a 1:5 ratio (one leader for every four members) with the objective of working and learning together [6]. By the same token, the "Rehabilitation Army," also known as "የልማትት ሰራዊት," also emerged in government offices and among farmers by uniting in groups of one to five. In a week or two, students meet in the school compound to exchange knowledge on a particular subject, while in the same time frame, the party members of the 1:5 group engage in "a cell lesson study" (a discussion on the political agenda of ruling party, known as the EPDRF). The discussion points may sent form higher official or given by the district party reader(s). The administrative bodies firmly ordered the group leader to follow the discussion point. After discussion, the group leader was organized the issues raised and reported to the district party leader. The district part leader then reported to a higher official (Head of ruling party). The farms follow in the footsteps of the government workers. At the time, the "Educational Army" and "Rehabilitation Army" issues were get more media coverage. There was a ruling party slogan always used in Afaan Oromoo in saying "Dhimmi raayyaa, dhimma jirachuu fi jirachuu dhabuutti!" Its lateral meaning is "The purpose of collaborative is the issue of either to survive or not!" This resulted, negative sentiments regarding the use of collaborative learning in education. The goals of collaborative learning in the 21st- century were substantially different from what was being done in schools under the guise of collaborative learning at that time. Collaboration skill is one of crucial 21st-CS used education 4.0. Therefore, teachers and students should make attitudinal change about collaborating learning and apply collaborative learning, collaborative problem solving, teamwork and cooperation during chemistry instruction to develop collaboration skill.

Teaching in the 21st century "one-size-fits-all" is a gigantic approach and penance system [38], it is no longer relevant to 21st century learning. Teachers should have to focus on individual developmental and personalized learning for each student. According to MI theory there are 9 different intelligences [18] which are correspond to the 7 learning styles such as visual, aural, verbal, physical, logical, social and solitary [19]. In line to this, Lerman and Morton [51] informed that in Columbia College, the innovative science curriculum had made projects for non-science major student using each individual skills and talents on the bases of personal interest, or cultural background to express their knowledge of science in an innovative and ingenious way. During the conduct of the projects learners presented learning of science in multiple ways by utilizing visual, audio, video, bodily kinesthetic, scripts, 3-dimensional art and music, own their interests motivate them to learn incorporating technology in the digital age of learning. Students present their findings using skills which they feel most competent, comfortable, and talented which embrace the audiences with new ideas and new ways of looking at scientific material. Also Sahin [52] stated that in the information age instruction should be designed based on individual needs. However, what the above mentioned scholars suggested were not yet touched the government SSs of study area. Teaching and learning system were still working in spirit of industrial age education system. Teachers were at the center of learning and students were simply watching what central player were doing. Because they did not get chance to play with the central player (teacher) or take the role of center by own self. Therefore, to address the individual learning style teacher should prepared tailored instruction during chemistry lesson integration with 21^{st}-CS that give chance for students to learn their own pace.

Students reacted to the use of digital technology in saying that "it is prohibited to bring any electronic materials into the school compound..., however, the school environment does not provide an appropriate setting for searching, creating, or sharing information related to the chemistry lesson." Students have the potential for personalized technology, such as mobile devices and tablets. Notably, if students choose to bring these electronic materials to school, they would incur charges ranging from 500 to 1,000 Ethiopian Birr, equivalent to 5 to 10 US dollars. The schools by themselves considered that students' use of electronic materials in the school compound as misconduct. Prohibit of any electronic materials as school regulation that posted in Amharic says "ማንኛውም ዓይነት ኤሌክትሮኒክስ ላፕቶፕ፣ሞባል መገልገያዎች በትምህርት ቤት ግቢ ይዞ አለመገኘት።" Its lateral meaning is "Any electronic materials such as laptops or mobile phones are not permitted in the school compound." In contrary, the Federal Ministry of Education [7], stated that textbooks and reference books of SSs are digitalized to make the content reachable through e-learning using audio and video formats, tutorials, and online courses, etc. Teachers and students access the digitalized content using computers, mobile phones, tablets, radios, etc. at anytime, anywhere. In and out of the classroom teachers and students can access the content using digital media. For teachers and students tablets loaded with teaching and learning materials and other digital resources will be provided for all high school to foster learning.

In fact, in the office of administrative bodies and staff, there was an internet connection, but emphasis was not given to use internet in the classroom as connectivist learning theory recommends. Since the schools did not provide good learning environment (digital technologies such as computer hardware, chemistry software, LCD, internet or e-learning materials) for students to understand the abstract concept of chemistry, to search, create and share knowledge, and to develop another 21^{st}-CS such as creativity, critical thinking, decision making, collaboration, communication , self-regulating. During observation the researchers were recognized that students learn IT as a subject and practices computer in the computer lab, but no favorable conditions to use internet in the classroom regarding to chemistry lessons or no practice of technology during chemistry lessons in the computer lab to develop 21^{st}-CS such as collaboration skills, complex communication skills, information, technology, digital literacy skills.

According to Connectivist learning theory students' exchange of knowledge through a network of humans and non-humans (artifacts- concrete conveyors). Concrete conveyors are physical objects in the classroom whose function is to explicitly display representations of knowledge. This category includes instructional technology artifacts such as computers and computer projectors, projection screens, document cameras, television monitors, and videocassette recorders (VCRs). In the digital world students will learn from anywhere, anytime by making connection, which means that students plug in to social interaction, flows of information/exchange of knowledge Reference [15]. Nowadays, technology is the part of the instructional design to create effective and meaningful learning with the integration of theories and technology. It is important to prepare a classroom environment for effective technology use. Integrating educational technology to education refers to the process of determining which electronic tools and methods for implementing them are appropriate for given classroom situation and problems [34]. This requires selecting best instructional materials for matching content, strategies of teaching-learning process. Therefore, chemistry teachers should use the framework of TPACK to integrate technology to the lesson. Because as [36] suggested that students can understand the abstract concepts of chemistry in using of multimedia tools that integrate the animation of molecular models, video clips of chemical equilibrium/simulations, which provide opportunities to visualize chemical processes at the sub-microscopic level that assist students' to understand the three-dimensional structures.

Overview of the development of 21^{st}-CS, utilization of technology and its effect, and subject knowledge acquisition reported by project Tomorrow, as cited in AACE [38] revealed that use of technology in the classroom students are more motivated to learn, apply their knowledge to practical problems, and possession of their learning. They also reported that students use of technology developing key 21^{st}-CS such as creativity, collaboration, and problem-solving and critical-thinking skills; thus effectively preparing them for future success in the workplace. Tsourapa cited in [5] pointed that teachers with positive attitudes are more likely to use technological tools and foster the development of 21^{st}-CS, whereas negative attitudes may limit such potentials. According to Brown cited in [5], negative attitudes may limit motivation and all likelihood, because of decreased input and interaction. To summarize, students use of technology help them to understand the abstract concept of chemistry and foster the development of other 21^{st}-CS. The investigators suggested that education actors must resolve the conflicting of idea between digital native and digital immigrates. Students are digital native the need to use technology to search, create and share information simultaneously [39], whereas digital immigrants (some teachers and administrative bodies) keep aside the use of technology. Since the need sequential learning that as they accustomed before, however, such thinking no longer valid in the 21^{st} century learning.

According to MoE [7], the former teaching-learning process emphasis on acquisition of knowledge, but not how it do. The majority of school systems do not adequately build students in line to 21^{st} century learning. As a result, education system was reformed to equip students' with 21^{st}-CS. However, the classroom observation, FGD, interviews and secondary data sources results revealed that 21^{st}-CS, such as creative and critical thinking, problem solving, collaboration and sophisticated communication, information, technology, and digital literacy skills were not yet being implemented. The teaching-learning process of the government SSs of study must align with education 4.0 to benefit individually, socially, nationally as well as internationally. Because the World Economy no longer pays for what people know but for what they can do with what they know [53].

A Jonckheere-Terpstra test for ordered alternatives revealed that there was no statistically significant trend of higher medians perceptions, attitudes, and awareness scores with higher levels of practices of 21^{st}-CS (from "absolutely not familiar," "not familiar," "familiar," to "absolutely familiar.") The researchers, therefore, fail to reject the null hypothesis in all cases. So that multiple comparisons are not performed because the overall test does not show significant differences across samples. A Jonckheere-Terpstra test confirmed that there were no statistically significant differences in the practices (implementation) of 21^{st}-CS in chemistry education by teachers and students regarding their level of perceptions, attitudes, and awareness. Even though neither teachers nor students were rated the higher level of awareness (5 = I know very well), A result obtained from the Jonckheere-Terpstra test was a good indicator that awareness not changed the perceptions and attitudes of chemistry teachers and students towards the practices (implementation) of 21st-CS. In another words, the participants had no adequate awareness about the practices (implementation) of 21st-CS in chemistry education in the government SSs of the study area.

Kendall's tau-b correlation showed that the association between awareness, perceptions, and attitudes was significant, but not strong. There was no significant correlation between the practices of 21st-CS and the awareness, perceptions, and attitudes of chemistry teachers and students. This was evident that even if, chemistry teachers and students had awareness (moderate), perceptions (high), and attitudes (high) towards practices (implementation) of 21st-CS, Kendall's tau-b correlation results showed that the three domains had no significant correlation with practices (implementation) of 21st-CS. The correlation between chemistry teachers' attitudes and practices of 21st-CS has an inverse linear relationship. These results were good indicators of teachers and students' level of awareness, perceptions, and attitudes towards practices (implementation) of 21st-CS overestimated what actually exist during chemistry lesson.

6. Conclusion

In the knowledge-based economy, soft skills (21st-CS) predominate over content knowledge or hard skills [54]. Therefore, we teach students the future, not as we learned before, spoonful feeding learning irrelevant to 21st century learning. With this vein, education actors from student to Minister of Education must give equal emphasis for both knowledge and soft skills in line to learning in the 21st century. The teaching-learning process such as instruction, assessment, learning environment, professional development must aligned with education 4.0. Ignoring of digital technology in teaching-learning process is cumbersome to survive in the digital age. So that the teaching of chemistry education in the government SSs of Addis Ababa City Administration need attention and awareness creation to align the system of education in the context of the current global demand of the knowledge-based economy. The researchers concluded that there was a discrepancy between expectations and actually going on concerning practices (implementation) of 21st-CS in chemistry education in SSs. Hence, high and favorable perceptions, high and positive attitudes accompanied with moderate awareness had not resulted the actual practices (implementation) of 21st-CS in chemistry education in the government SSs (grades 9 and 10) of Addis Ababa City Administration.

Teaching-learning processes had not aligned with learning in the 21st century. Which means that grades 9 and 10 students had not get opportunities to practices 21st-CS in chemistry education. If this condition not revised students had no more chance to practice and prepared for the next schooling, workplace, and their life. Also a great deviation from learning in education 4.0 could be problematic getting high skilled workforces in the workplaces that performed by digital technology as well as individually and collectively difficult to succeed in the knowledge-based economy. Teacher's roles and responsibilities make them forefront line to create awareness, integrate and implement 21st-CS in chemistry education. The false belief that teachers are professional, know how to teach, assist and assess 21st-CS integration with chemistry education should be reversed. Therefore, professional development should provide concerning teachers and students' characteristics in the 21st century, how to teach, assist, and assess student's learning of 21^{st}-CS. Teachers and students should fully understand that the process of learning 21^{st}-CS such as creative and critical thinking, creativity, problem solving, collaboration, complex communication, etc. is not as straightforward as content knowledge. With this context, they should plan student-centered method to integrate and implement 21^{st}-CS with chemistry contents. Incorporating instructional materials (artifacts), appropriate teaching, and assessment methods foster 21^{st}-CS. The role of teachers must shifted from transmission of knowledge to facilitator in encouraging and assisting students to apply constructivism and connectivism learning approaches. Also initiating students to use their learning styles to develop 21^{st}-CS and understand chemistry concepts deeply.

7. Limitation

The researchers were not reached on the final conclusion why teachers must of the time use their native language during instruction rather than follow the curriculum ordered. This need further investigation in line to the role of medium of instruction and effective communication. Also the problem of students' face difficulty to read chemistry need investigation to alleviate the observed problem. Another point chemistry teachers were not interested to state the teaching aid used as well as they did not use during the lesson. It is necessary to identify why they restrain themselves than using teaching aid for certain chemistry topics. Because chemistry learning need hand on, heart on and mind on activities. These three things can be subsumed in constructivists learning perspectives, connectivits learning views and theory of multiple intelligence/ individual unique learning preferences.

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