RESEARCH ARTICLE

Students' achievement of the 21st century skills in the process of teaching and learning biology among science students

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Abstract: Nearly one in five pupils in OECD nations do not possess the fundamental knowledge and abilities necessary to get by in today's communities (OECD, 2019), which is a sign of exclusion. There is an unfairness in that students from low socioeconomic origins are twice as likely to be low performers, suggesting that social or personal factors prevent them from fulfilling their educational potential. This study intends to investigate the achievement of the 21st Century Biology Skills Test (21CBST) and to compare it to students' level of socio-economic status. The result (TIMSS) (2015) revealed that Indonesian students failed to achieve minimum standards in Science and Mathematics, with 33.3% achievement in science and 35% in mathematics for content domain and 33,3% in the cognitive domain. Comprising 37 multiple choice items, the 21st Century Biology Skills Test (21C-BST) includes representatives from five domains which are; i) Digital Age Literacy, ii) Inventive Thinking, iii) Effective Communication, iv) High Productivity, and v) Religion, Health and Civic. The respondents comprised 210 form students who took biology subject in school. The study revealed that students from high socio-economic status scored higher than their counterparts from low socioeconomic status. This paper concludes with some practical suggestions for improving students' 21st-century skills, particularly within the context of biology teaching and learning.

Keywords: Digital age literacy; effective communication; high productivity; inventive thinking; spiritual value

Introduction

Indonesia is currently committed to the Government Transformation Program which includes implementing a new curriculum to transform the national education system. In this transformation plan, Indonesia focuses on developing human capital that can compete globally (Rukmana, 2015). To realize this goal, Indonesian student's achievement especially in Science and Mathematics must be equal to or higher than their counterparts in other developing countries. Therefore, in order to face these challenges, students must be equipped with sufficient and updated scientific knowledge (Romero et al., 2017) and new emerging skills (Struyf et al., 2019) in order to compete with the rest of the world in the current global economy (Rachmatullah et al., 2018).

Issues of which components of skills should be emphasized in 21st-century education are currently widely discussed and debated all around the world (Wahono et al., 2021; Lange et al., 2022; Alt & Raichel 2020; Hordern, 2023). Nevertheless, it should also be kept in mind that any effort to inculcate 21st Century Skills in teaching and learning science should be implemented in line with the development and findings from current international as well as national research (Kayan-Fadlelmula et al., 2022; Sun et al., 2023).

Most school science textbooks did not stress practical knowledge that could be applied in everyday life (Alt & Raichel, 2020; Bwalya & Rutegwa, 2023; Care et al., 2019). It was reported that 20% of Indonesian students failed to achieve minimum standards in science and mathematics. Indonesia's performance improvement in PISA 2015 is significant, but its performance is still below the OECD average. This will then affect the workplace where (Pillay & Elliott, 2001; Kryukova et al., 2022) workers only put minimal effort on technical and social competencies when executing their jobs. This has resulted in the production of a workforce (Remenick & Bergman, 2021) that is incompetent at the international level. This scenario stresses on the need to integrate 21st Century Skills in science teaching and learning in school (Audrin & Audrin, 2022; Bwalya & Rutegwa, 2023; Care et al., 2019).

Another aspect that needs to be considered is the students' socioeconomic profile. As shown earlier in other research (Chen et al., 2018; Berkowitz et al., 2017), students' parental socio-economic status has a significant relationship to students' achievement. PISA 2015 shows that the average score of students from High Socio-Economic backgrounds (HSE) can be higher than the students who came from Low Socio-Economic background (LSE). Scores in mathematics and science of Indonesian students coming from the HSE family can still be lower than the international average (Nugrahanto & Zuchdi, 2019; Hartono et al., 2022; OECD, 2019).

According to extensive study, a child's family is the most accurate indicator of their future academic performance (Kyriakides & Creemers, 2018) and in many situations their ability to enter well-paying and high-status employment (Gustafsson et al., 2018). Typically, learning obstacles for children from low-income and uneducated homes are numerous (Charalambous et al., 2018). Fewer educational resources, such as books, games, and interactive learning items in the home, are frequently correlated with lower household wealth (Reardon, 2018). Higher socioeconomic level parents are more likely to start out by giving their kids resources at home and financial assistance for their own study. They are more likely to provide a dynamic home environment to foster cognitive development because they are more likely to have higher levels of education (Scherer & Siddiq, 2019). Results from earlier PISA indicate that school systems might be able to lessen the effect of families' socioeconomic situation on the outcomes of their children's lives. Schools can assist direct resources toward underprivileged kids, resulting in a more equitable distribution of learning opportunities and results (OECD, 2019; Downey & Condron, 2016).

With an average effect value of 0.27 (95% CI: 0.28-0.29) for a sample from the United States, Sirin confirmed a medium to high relationship between SES and accomplishment (Liu et al., 2020). Same meta-analysis using 215,649 students from 78 different independent samples. The sample from mainland China showed a moderate relationship between academic performance and SES. Although many studies have addressed the problem of students' achievement in science and its relationship with students' socioeconomic status, very little research have been conducted to study the issues within the context of Biology teaching and learning. However, the underlying mechanism of how family SES works on academic achievement remains unclear.

This paper will report the study that has investigated the Indonesian students' achievement in the Indonesian 21st Century Biology Skills Test (21CBST). Besides that, students' socio-economic status and home learning environment will also be profiled to see if they influence students' achievement in 21CBST. The purpose of this study is to profile the achievement of the Indonesian 21st Century Biology Skills Test (21CBST) among high school students in Indonesia. Specifically, the objectives are: to determine whether students' achievement in the 21CBST differs significantly according to their socio-economic status. This study examines the relationship between socioeconomic status and science student achievement. First, consider the stark socioeconomic disparities that can be found inside and

between the city. Additionally, it covers how student performance differs based on the subject area in which they are enrolled in school, even among kids with identical socioeconomic backgrounds. The study also shows how some educational systems might flourish while reducing the link between science achievement and a student's socioeconomic position.

Method

In total, 439 students (age range = 15-17 years, which consisted of 261 females and 178 males) across several senior secondary schools in East Java Province, Indonesia were recruited as participants in this study. From January through March 2023, three months of the survey were conducted.
This study employed a quantitative design using a survey research method to students who are studying Biology at schools. The sample is strategically drawn according to their socio-economic status (High and Low). The questionnaire used in this study contained 37 questions. Domains and characteristics of skills that are included in the development of 21CBST items are shown in Table 1.

Table 1. Name of the table Indonesian 21st Century Biology Skills

No	21st Century Biology Skills	Number of questions
	A. Digital Age Literacy	9
1	Know how to perform scientific investigation and how to verify result	
2	Use science knowledge in making decisions related to life, problem-solving, and making judgments	
3	Competent in handling various media to access accurate and valued information to make analyses before taking action	
4	Can well differentiate between fact and fiction or knowledge and opinion	
5	Understand different cultures and respect different beliefs because science in social contexts can have many true answer	
	B. Inventive Thinking	10
6	Independent, plan and manage time effectively	
7	Able to solve complex problems and can adapt way of thinking and attitude to suit the current situation	
8	Showing a positive attitude in finding knowledge, and opportunities and daring to take risks	
9	Able to determine problems, find alternatives, explore new choices to increase the quality of human life and protect the environment	
10	Determine the problems in economics, cost, and profit in expecting impact of economic changes	
	C. Effective Communication	8
11	Realize the importance of cooperative traits and good leadership attitude	
12	in group work Able to understand and control one's emotions and able to take care of others'feelings in social interaction	
13	Showing integrity and balance in life	
14	Science in a social context have moral, ethics, and politics	
15	Apply technology in communication to share information across geography,language and culture differences	
	D. High Productivity	5
16	Manage and solve problems effectively and efficiently for all	
17	Analysis and choosing information, sources, and technology to give the optimum product	
18	Invent and apply technology to increase welfare, quality of life, and environment	
	E. Religion, Health, and Civic	5
19	Invest money in health programs	
20	Realize that technology helps in improving human life by using natural sources given by God	
21	Use skills and knowledge to help in the country's development	
	Total	37

The dimensions of the 21st-century skills are known theoretically because the instrument was designed in accordance with the criteria in the questionnaire created by (Lemke, 2002; Osman et al., 2010).

Therefore, only confirmation using confirmatory factor analysis (CFA) is required. The instrument has been validated and reliability-tested prior to collecting data. The question further called The Indonesian 21st Century Biology Skills Test represents five domains. Four out of five domains were based on NCREL: enGauge 21st Century Skills 2003 characteristics to help students growing up in today's digital world. The four components are i) Digital Age Literacy; ii) Inventive Thinking; iii) Effective Communication; and iv) High Productivity. The fifth domain which is Spiritual value has been empirically added by previous researchers (Osman & Marimuthu, 2010). All students completed a demographic question (age, gender, parents' level of education, parents' occupational status or what jobs the parents held, and annual household income). Student completed the demographic questions by taking the questionnaire home and consulting with their parents. The students were asked to complete the self-concept scale by themselves.

The legitimate questionnaire is then created as a Google Form. Through the social media platform WhatsApp (WA), the links are delivered to the students in each district and city. WA was chosen because every student has WA, making it simpler to distribute questionnaires. The student's voluntarism determines whether or not the questionnaire will be filled out. Additionally, the submitted data is anonymised and kept private. As a result, snowball sampling was used to pick the respondents for this study (Frey, 2018).

Socio Economy Status (SES)

There is agreement that a stable measure of SES should include education, occupation, and income even though there is no universally accepted method for doing so (Bradley & Corwyn, 2002). In order to assess the children's family SES, we employed the parents' degree of education, occupation, and annual household income in this study. A seven-point Likert scale was used to assess the educational attainment of the parents: 1 for primary grades 3 or lower, 2 for primary grades 4 to 6, 3 for middle school, 4 for high school, 5 for three-year colleges, 6 for four-year universities, and 7 for postgraduate degrees. The Occupational Prestige Scale (Liu et al., 2020), which rates 81 professions with scores normalized as 0-100, was used to gauge the occupation of parents. The higher the score, the more prestigious that profession is. A ten-point Likert scale was used to calculate annual household income. Likert Scale 1 = less than 2.000.000; 2= between 2.000.000 – 3.000.000; 3= between 3.000.000 – 4.000.000; 4= between 4.000.000 – 5.000.000; 5= between 5.000.000- 6.000.000; 6= between 6.000.000- 7.000.000; 7= between 7.000.000 – 8.000.000; 8= between 8.000.000 -9.000.000; 9=between 9.000.000- 10.000.000; 10= more than 10.000.000 rupiah per month.

Results and Discussion

The analysis of the achievement scores of the five subcomponents in 21CBST revealed substantial differences (Table.2). Students from high socioeconomic backgrounds (HSE) scored significantly higher than students from low socioeconomic backgrounds (LSE) in all subcomponents of 21CBST except Effective Communication. From the analysis, the difference in the mean score of students' achievement in the Digital Age Literacy subcomponent is [t =2.56, p<.05]. The mean score of students with HSE (m=11.53) is higher than the mean score for students with LSE (m=10.03). The difference in the mean score of students' achievement in the Inventive Thinking subcomponent is [t=3.14, p<.05]. The mean score of students with HSE (m=12.81) is higher than the mean score for students with LSE (m=11.16). However, there was no significant difference in the mean score of students' achievement in the Effective Communication subcomponent [t= -.20, p>.05]. The negative value of t shows that the mean score of students with HSE (m=10.22) is lower than the mean score for students with LSE (m=10.32). The second last subcomponent is High Productivity. The difference in the mean score of students' achievement in High Productivity subcomponent is [t=2.72, p<.05]. The mean score of students with HSE (m=6.57) is higher than the mean score for students with LSE (m=5.63). Lastly, the difference in the mean score of students' achievement in the Religion, Health, and Civic subcomponentsis [t =2.33, p<.05]. The mean score of students with HSE (m=7.20) is higher than the mean score for students with LSE (m=6.33).

The overall students' mean score in 21CBST is lower than the national result in TIMSS 2015. However, UNICEF Indonesian Communication in 2008 stated that the level of achievements for science in Indonesia was above the international benchmark setting. When comparing the achievements according to students' SES, this study confirmed that students with HSE score significantly higher than students with LHE in all 21CBST components except for Effective Communication. Effective Communication component includes teamwork (Fan & Wang, 2022), cooperation (Chirwa & Boikanyo, 2022), and interpersonal (Binkley et al., 2012) skills which are related to cooperative teaching and learning techniques applied by the teachers (Aktamis & Ergin 2008; Cao et al., 2017). The fact that students with HSE or LSE show no difference in Effective Communication Skills is because both groups went through the same learning process at school (Lemke, 2002). The overall mean score achievement difference is partly due to other learning resources for example tuition, calculator, dictionary, computer, books, and

learning space at home (Hanrahan 2009; Pathoni et al. 2022; Lehmkuhl et al. 2021; Ye et al. 2023).

Table 2. BCST Min Score Differences between Students with HSE And Students With LSE

CBST	Socioeconomic status	Mean Score	Standard Deviation	t-test	Sig.
Digital Age Literacy	HSE	11.53	4.76	2.56	.011
	LSE	10.03	5.22		
Inventive Thinking	HSE	12.81	4.42	3.14	.002
	LSE	11.16	4.40		
Effective Communication	HSE	10.22	3.94	-20	.839
	LSE	1032	4.19		
High Productivity	HSE	6.57	2.82	2.72	.007
	LSE	5.63	3.04		
Religion, Health and Civic	HSE	7.20	3.09	2.33	0.20
	LSE	6.33	3.20		

This study also investigated the impact of computers on students' achievement in 21CBST. TIMSS in 2015 report revealed that students from homes with a computer had science achievements above those from homes without one (Barrios Aguirre et al. 2021; Gneezy et al., 2003). However, results from this study are consistent with TIMSS (2015) due to the finding that computers have a significant interaction effect. It is also related to a survey internationale by PISA showing that only 1 of 4 schools in Indonesia have computers (49,78%). Meanwhile, internationally 2 out of 4 schools have computers, and a further 36%of schools require serious improvement (OECD, 2015).

TIMSS stated that, from an educational perspective, using a computer is more important to students than merely having one at home. Nugrahanto and Zuchdi (2019) affirmed that students' computer literacy in Indonesia was moderately high (66.67%) which indicated that if the mean score is less than the cutting point of 50%, students were considered computer illiterate. Therefore, if the students do not fully use computers for the sake of exploring knowledge, then the computer is rendered useless. Finally, to inculcate Indonesian 21st Century Biology Skills to improve students' achievement, and develop well-balanced individuals, teachers should apply the use of computers in the learning and teaching process (Berisha & Vula, 2021; Lange et al., 2022; C. Chen et al., 2023; Gamage et al., 2022). Moreover, this study indicated that some studentswith LSE do not have computers at home. Therefore, schools must provide an opportunity for students to explore and discover knowledge on their own with the use of computers and the Internet (Gladstone & Cimpian 2021; Haleem et al. 2022; Donham et al. 2022).

Conclusion

The study revealed that students from high socioeconomic status scored higher compared to their counterparts from low socioeconomic status. This paper concludes with some practical suggestions for how to improve students' 21st-century skills, particularly within the context of Biology teaching and learning. Finally, to inculcate Indonesian 21st Century Biology Skills to improve students' achievement, and develop well-balanced individuals, teachers should apply the use of computers in the learning and teaching process. Moreover, this study indicated that some students with LSE do not have computers at home. Therefore, schools must provide an opportunity for students to explore and discover knowledge on their own with the use of computers and the internet

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Limitations and Suggestions for Future Research

A few limitations are noteworthy in this study. First, the study context was limited to a small biology teacher, and thus the findings may not be applicable to other disciplines. Future research could expand the study in diverse educational settings. Future studies could investigate more closely the effect of strategies and technologies on students' learning outcomes in 21st-century skills.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

R. Pamungkas: conceptualization, formal analysis, writing original draft, analyze data, methodology, data curation. **H. Suwono:** review, methodology, visualization, analysis, data curation. **H. Susilo:** validation, supervision. **I. Ibrohim:** supervision. **R. Marlina:** translator. **T. M. Sari:** Translator.

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