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Empowering Future Innovators: The Role of ITRED's 21st Century Skills Program in Preparing Quezon City Students for Industry 4.0

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Abstract:- Rapid technological advancement and automation are hallmarks of the Fourth Industrial Revolution, which calls for a workforce with high technical skills and creative problem-solving abilities. This study looks at how the 21st Century Skills Program of the Institute of Technological Resources and Entrepreneurial Development (ITRED) has affected Quezon City public high school students' readiness for Industry 4.0. Using a mixed-methods approach that includes both quantitative assessments and qualitative interviews, this study assesses how well the curriculum has helped learners become more computer literate, robotics competent, and entrepreneurial.

Students' skill with computer programs, their comprehension and application of robotics, their readiness for Industry 4.0, and their growth as entrepreneurs are among the key characteristics that are evaluated. The program's overall impact on the educational environment is examined, as well as student participation and attitudes toward innovation and technology. The results show that students' technical knowledge and skills have significantly improved, and they are also showing greater interest in and involvement with technology and entrepreneurship.

Additionally, the research highlights the quality of program implementation, the adequacy of resources provided, and the competency of instructors as critical factors contributing to the program's success. The integration of ITRED's programs into the school curriculum and the supportive role of school administrators and teachers emerged as vital elements in fostering a culture of innovation and continuous learning.

This paper concludes that ITRED's 21st Century Skills Program plays a pivotal role in preparing Quezon City students for the demands of Industry 4.0, equipping them with the necessary skills to thrive in a technologically advanced and entrepreneurial-driven economy. The study's insights offer valuable implications for educational policymakers, curriculum developers, and educators aiming to bridge the digital divide and cultivate future innovators in the Philippines and beyond.

1. Introduction

The introduction an immense change in the nature of work and business has resulted from the advent of business 4.0, a phrase referring to the confluence of cyber-physical systems, the Internet of Things (IoT), artificial intelligence (AI), and enhanced automation. The demand for individuals with both technical and 21st-century skills is becoming more pressing as a result of this shift in the definition of jobs and the skills required to do them (Schwab, 20 19). In this paradigm, educational institutions face the critical challenge of preparing students to thrive in a future marked by rapid technological advancements and shifting industry demands.

As one of the Philippines' most vibrant cities, Quezon City reflects the general global trend of fast increasing sophisticated technology integration across a wide range of industries. Urban environments like this one offer a special chance and a pressing need to give the next generation of young people the skills they need to succeed in the complicated world of Industry 4.0. This requirement led to the creation of the Institute of Technological Resources and Entrepreneurial Development (ITRED)

Computer Literacy with Robotics Program with 21st Century skills implementation, which prioritizes students' holistic development by teaching critical 21st-century skills in addition to technical proficiency (Department of Education., 2021).

In today's educational discourse, there is widespread recognition of the importance of 21st-century abilities, which include critical thinking, creativity, cooperation, and communication. These abilities are thought to be essential for promoting innovation and economic progress in addition to being critical for individual achievement (World

Economic Forum, 2020). In order to improve students' readiness for the workforce and their ability to contribute to technical and industrial breakthroughs, the ITRED program's 21st Century Skills Program focuses on developing these competencies in students.

Even though these abilities are acknowledged as being important, there is a significant skills gap in the present educational frameworks. Numerous educational systems are falling behind in incorporating these competencies into their curricula, according to studies (OECD European Commission, 20 19). This disparity is especially noticeable in poorer nations, where the problem is made worse by limited resources and uneven access to technology. In order to guarantee that the future workforce in the Philippines is not only technically proficient but also flexible, creative, and cooperative, it is imperative that this gap be closed (Asian Development Bank, 20 20).

The goal of ITRED's 21st Century Skills Program is to close this gap by offering a thorough educational framework that combines the acquisition of critical soft skills with cutting-edge technological training. Using the most recent developments in pedagogy and technology, the program's curriculum is designed to promote an atmosphere of experiential learning, critical thinking, and problem-solving (UNESCO, 2021).

The purpose of this study, "Empowering Future Innovators: The Role of ITRED's 21st Century Skills Program in Preparing Quezon City Students for Industry 4.0," is to assess the results and efficacy of ITRED's programs. In order to shed light on how ITRED is addressing the skills gap and preparing students for the needs of the contemporary industrial landscape, this research will examine the program's curriculum, teaching practices, and outcomes. For a thorough assessment of the program's efficacy, a mixed-methods approach will be used in the study, including quantitative and qualitative data (European Commission., 2020).

This research emphasizes how important innovative educational programs are in shaping the workforce of the future by placing the ITRED program in the larger context of global educational and industrial trends. Offering research-based advice to decision-makers, teachers, and other stakeholders who are dedicated to fostering the next wave of innovators in Quezon City and beyond, it seeks to add to the conversation on workforce development and educational reform.

2. Research Framework

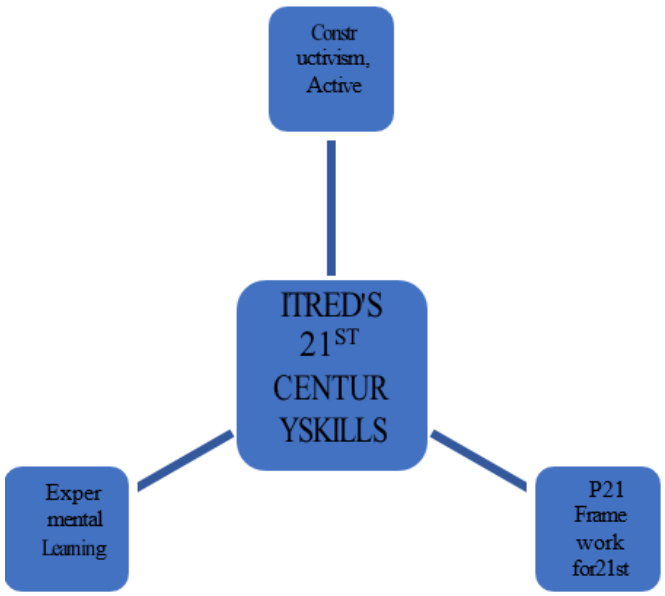

Figure 1. ITRED'S 21st Century Skills Program

Constructivism in ITRED's Program; Through project-based learning, students actively participate in their education; Social learning and deeper comprehension are fostered by collaboration with classmates and instructors; One such example is when students collaborate in teams to design and build a robot, putting their knowledge to use in a collaborative setting.

Experiential Learning in ITRED's Program, through practical projects, students gain real-world experience. The curriculum includes reflective exercises that help students see and understand what they are learning. Example: Following the construction of their robot, students consider the difficulties encountered, brainstorm enhancements, and test out novel concepts.

The P21 Framework Integration, showcases students have real-world experience through practical projects. Reflective exercises are incorporated into the curriculum to assist students in seeing and comprehending what they are learning. Example: After building their robot, students reflect on the challenges they faced, come up with improvements, and try out new ideas.

The P21 Framework for 21st Century Learning, experiential learning theory, and constructivist concepts are all combined in the theoretical framework of ITRED's 21st Century Skills Program to produce a holistic educational approach. By ensuring that students acquire the skills needed to succeed in Industry 4.0, this integration positions them to make valuable contributions to the workforce in the future.

2.1 Conceptual Framework

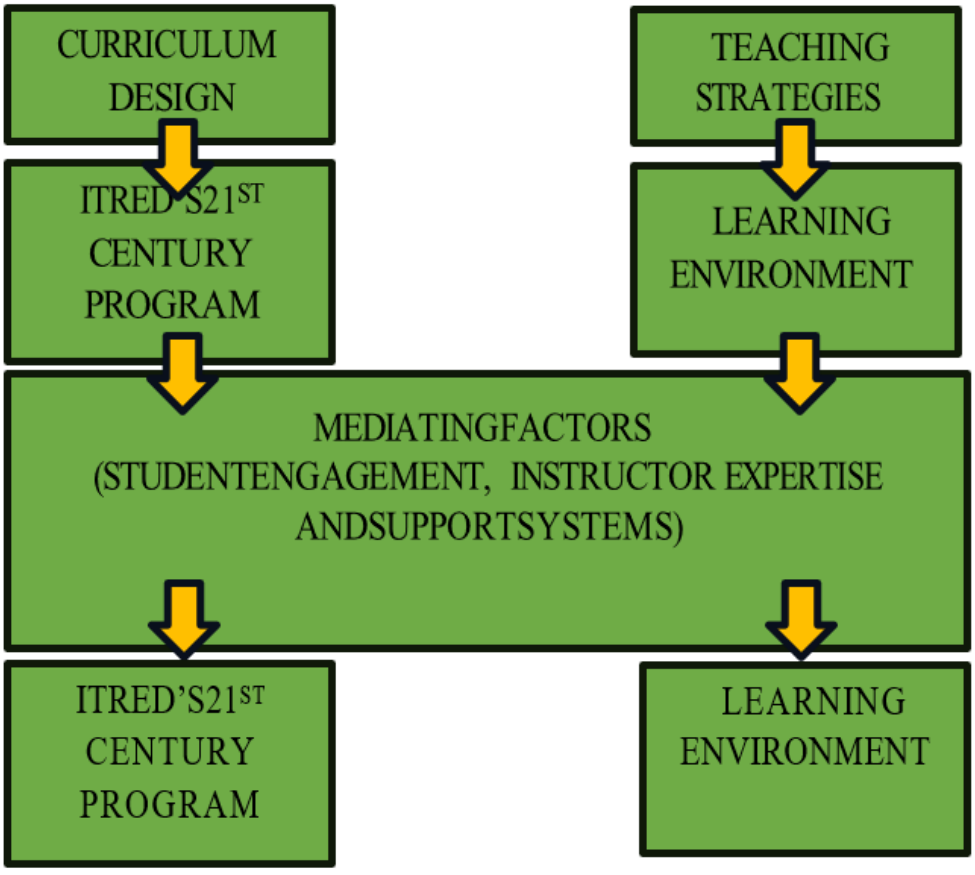

Figure 2. "Empowering Future Innovators: The Role of ITRED's 21st Century Skills Program in Preparing Quezon City Students for Industry 4.0".

The conceptual framework demonstrates how curriculum design, instructional techniques, and learning environments are all interrelated in forming students' abilities and readiness for Industry 4.0. This framework

offers a thorough knowledge of how ITRED's 21st Century Skills Program seeks to give Quezon City students the skills they will need for the workforce in the future by considering the mediating elements.

As shown in Figure 2. The linkages between the main elements of the study are outlined in the conceptual framework for the research paper "Empowering Future Innovators: The Role of ITRED's 21st Century Skills Program in Preparing Quezon City Students for Industry 4.0". The independent, dependent, and mediating variables that affect ITRED's educational program's results are identified in this framework.

The intention is to demonstrate how the elements of the ITRED program contribute to the acquisition of necessary skills and preparedness for Industry 4.0.

Curriculum Design: The curriculum of ITRED's program incorporates both technical and 21st-century abilities. To ensure real-world application and engagement, the design is built on project-based and experiential learning.

Teaching Strategies: Problem-solving exercises and practical activities are facilitated by the use of interactive and student-centered teaching methodologies. The goal of this tactic is to promote a dynamic learning environment.

Learning Environment: Through ITRED, students are guaranteed the support they need to succeed in their academic endeavors.

Mediating Factors: The program's efficacy is influenced by three factors: student participation, instructor skill, and the availability of support resources. These elements affect how well students learn and use the abilities that are taught.

Skill Development: Technical and 21st-century skill development is the main outcome that is measured. This involves technical expertise in robotics and IT as well as critical thinking, creativity, teamwork, and communication.

Student Preparedness for Industry 4.0: Evaluating students' readiness for Industry 4.0 workforce demands is the ultimate objective. This entails assessing their versatility, creative thinking, and general assurance in using their abilities in practical situations.

3. Objectives of the Study:

The main and purpose of this study, "Empowering Future Innovators: The Role of ITRED's 21st Century Skills Program in Preparing Quezon City Students for Industry 4.0," is to assess how well the ITRED program has prepared students for the demands of the industry by giving them the skills they need to succeed in the coming era. The following precise goals are the focus of this research: (1) Evaluate the 21st Century Skills Program's Curriculum Integration: Examine how ITRED's 21st Century Skills Program blends communication, teamwork, creativity, and critical thinking into its lesson plans and instructional strategies. This entails assessing how well the curriculum complies with international standards for 21st-century learning. (OECD European Commission, 2019). (2) Analyze Student Competency Development: To find out how much the ITRED program's participants' students are developing the skills needed for Industry 4.0. This covers both the hard skills needed for robots and information technology as well as the soft skills necessary for today's workforce. (World Economic Forum, 2020). (3) Examine the Effect on Student Industry 4.0 Readiness to ascertain the degree to which the ITRED program equips students to meet the challenges and seize the opportunities presented by Industry

4.0. This entails evaluating the students' preparedness to interact with cutting-edge technologies and their capacity to adjust to the rapidly changing industrial environment. (European Commission, 20 20). (4) Determine Strengths and Needs for Improvement: To determine the ITRED program's strong points and areas in need of improvement. This entails assessing the program's assets, instructional techniques, and general efficacy in reaching its learning objectives. (UNESCO, 20 21)

4. Methodology

4.1 Research Design

The methodical approach employed to assess the efficacy of the ITRED program is described in the study section "Empowering Future Innovators: The Role of ITRED's 21st Century Skills Program in Preparing Quezon City Students for Industry 4.0 ". The research design, participants, data collection techniques, and data analysis protocols are all included in this research.

Utilizing a mixed-methods research design, this study offers a thorough assessment of ITRED's 21st Century Skills Program by integrating quantitative and qualitative methodologies.

Quantitative approach was used to measure Students' skill development and readiness for Industry 4.0 w using a quasi-experimental design with pre- and post-test assessments; Surveys and standardized tests was used to measure changes in students' technical, critical thinking, creative, collaborative, and communication skills before and after program participation.

While the Qualitative approach was used to gather in-depth understanding of the experiences, viewpoints of students, instructors, and stakeholders was provided through interviews, and focus groups. The program's effects on students' engagement, learning processes, and Industry 4.0 preparation was investigated using qualitative data.

4.2 Research Locale

Students registered in ITRED's 21st Century Skills Program in Quezon City specifically enrolled in Diliman College. Here is a set of sample survey questions tailored for evaluating ITRED’s 21st Century Skills Program (SUNDAY CLASS COMPUTER LITERACY WITH ROBOTICS) and its effectiveness in preparing Quezon City students for Industry 4.0. Use estimations or past enrollment statistics if the precise number of students is unavailable.

4.3 Research Respondents

A total of fifty-nine (59) respondents were selected by means of random sampling methods was used to enrolled students enrolled in the during the SY 2021-2023.

Table 1: Profile of the Respondents of the students

Description	Category	Percentage
	Female	60%
	Male	35%
	Non-binary / Third gender	2%
	Prefer not to say	3%
	Under 13 years old	3%
	13-15 years old	70%
	16-18 years old	27%
Grade Level	Grade 7	17%
	Grade 8	12%
	Grade 9	41%
	Grade 10	29%
	Grade 11	1%
Ethnicity / Cultural Background Language(s) Spoken at Home	Public school	98%
	Private school	2%

Description	Category	Percentage
Average Household Income	Less than PHP 10 ,0 00	30%
	PHP 10,000 - PHP 20,000	20%
	PHP 20,001 - PHP 30,000	3%
	PHP 30,001 - PHP 50,000	7%
	More than PHP 10 0,000	3%
	Prefer not to say	37%
Parent/Guardian Education	Filipino	10 0.00%
	Filipino	98%
	English	2%
	Elementary School	4%
	High School	64%
	Vocational / Technical School	2%
	College / University (bachelor's	7%
	Graduate School (master's	5%
	Prefer not to say	18%
Accessibility to Internet at Home	Yes, stable access	93%
	Yes, but unstable access	2%
	No access to internet at home	2%
	Prefer not to say	3%
Transportation to School Current Mode of Learning	Walk	27%
	Public transportation (jeepney,	58%
	Bicycle	2%
	Motorcycle	13%
	Fully in-person	71%
	Hybrid (combination of	20%
	Fully online	7%
	Other	2%

4.4 Research Instruments

The Retrospective Survey Contained the Following Parts:

- Respondent's Profile: 10 items
- Part 1: Pre-Test and Pos-Test Assessments 25 items multiple choice
- Part 2: Survey Assessments 25 items 4-pt Likert scale
- Part 3: Semi-structured Interview questionaires 25 items

a) The questionnaires was subjected to Cronbach's alpha coefficient wherein any resultant coefficient equal of higher than 0.70 indicates that the instrument is deemed valid and reliable in terms of internal consistency. Based on the actual sampling used, i.e. the first 20% of respondents to the retrospective

survey, the validation yield a **Cronbach's alpha coefficient of 0.966** which means the research instrument is deemed valid with a very high reliability and internal consistency.

b) The reliability index was calculated using Cronbach's alpha. Using fifteen indicators, r = 0.906 is found for the variable (ITRED's 21st Century Skills Program in terms of Proficiency Using Software Application). The variable (ITRED's 21st Century Skills Program in terms Understanding the Industry 4.0 Concept) yields a result of r = 0 .936 with twenty-one indicators. The variable (ITRED's 21st Century Skills Program in terms of Business Planning and Strategy Formulation) yields a r = 0 .924 result with Twenty-four indicators. The variable (ITRED's 21st Century Skills Program in terms of Level of Interest in Technology and Entrepreneurship) yields a r = 0 .866 result with Eighteen indicators. ITRED's 21st

Century Skills Program in terms of Quality and Structure of ITRED Diliman College-REF Program Delivery) yields a r = 0.938 result with eighteen indicators. The variable (ITRED's 21st Century Skills Program in terms of Improvement in Technical Skills and Knowledge) yields a r = 0.927 value with fifteen indicators. The variable (ITRED's 21st Century Skills Program in terms of Integration of ITRED Diliman College-REF's Programs into the School Curriculum) yields a r = 0.934 value with fifteen indicators.

The Cronbach's alpha reliability test result is regarded as legitimate because the reliability index for the full survey questionnaire is 0.974.

Estimate	Cronbach's α	mean
Point estimate	0.974	413.898

c) Meanwhile the interview questionnaire was subjected to face validation by experts.

4.5 Data Gathering Procedure

In all the sample sizes for all the data gathering techniques (i.e. retrospective survey, expert interview, and benchmarking), purpose or judgmental sampling was used by the research proponent.

Table 2: Data Collection Tools

Tool	Description	Purpose	Implementation
Pre-Test and Post-Test Assessments	Standardized tests	Measure development skill	Multiple-choice questions, problem-solving exercises, practical tasks
Surveys	Structured questionnaires	Self-reported data on skills and readiness	Likert scales, open-ended questions, online and paper formats
Semi-Structured Interviews	One-on-one interviews	Detailed insights experiences into	Open-ended questions, audio-recorded, transcribed
Focus Discussions Group	Group discussions	Collective experiences perspedata and collectionctives	Facilitated moderator, transcribed by a recorded,
Classroom Observations	Observations of classroom activities	Assess curriculum implementation, student engagement	Standardized checklist, notes on instructional methods

4.6 Statistical and Data Analysis

Measures of central tendency (mean, median, mode) to summarize the average performance of students; Measures of variability (range, standard deviation, variance) to understand the spread of students' scores. While Paired t-Test was used to compare pre-test and post-test scores to determine if there is a significant improvement in students' skills after participating in the ITRED program.

ANOVA was also used to compare the means of different groups (e.g., experimental group vs. control group) to see if there are significant differences in skill development. Pearson 'r' correlations and Regression Analysis was used to examine the relationship between independent variables (e.g., curriculum design, teaching strategies) and dependent variables (e.g., skill development, readiness for Industry 4.0).

5. Results and Discussion

As presented in Table 1 the study revealed that the profile 60 % of the respondents are female and 35% male while 2% were non-binary / third gender and 3% prefer not to say. The researcher noticed that respondents age were 3% under 13 years old, 70% were between 13-15 years old, and the remaining 27% were between ages 16-18. The study also revealed that respondents were composed of 17% Grade 7 students, 12% grade 8, 41% grade 9, 29% grade 10 and the remaining 1% from grade 11. The study also indicates that 98% of the respondents' attended the Public School while the remaining 2% goes to the private school.

The average household income of the respondents were composed of 30% with less than Php 10 ,0 00, 20 % with Php 10,0 00 – 20,0 00, 3% with Php 20 ,0 01 – 30 ,000, 7% with Php 30,0 01- 50,00 0, 3% with more than Php 100 ,000 and the remaining 37% prefer not to say.

The researchers note that the respondents were 100 % Filipino in Ethnicity / Cultural Background. 98% speaks Filipino while 2% speaks in English in their homes.

The research also revealed that respondents' Parent/Guardian Education Level (Highest Attainment) consist of 4% finished Elementary School, 64% High School, 2% Vocational / Technical School, 7% College / University (bachelor's degree) and 5% from Graduate School (master's degree or higher). However, the remaining 18% Prefer not to say. Their education level.

The researchers noted that the respondent's accessibility to Internet at home reveals that 93% says Yes, they have stable access, 2% Yes, but have unstable access, 2% No access to internet at home and the remaining 3% prefer not to say.

The study also reveals that the respondents mean of transportation to school 27% walk their way to school, 58% took public transportation (jeepney, bus, MRT/LRT), 2% rode bicycle and the remaining 13% took motorcycle going to School.

The study also reveals that the respondent's current mode of learning consists of 71% fully in-person, 20 % via hybrid (combination of in-person and online), 7% full online while the remaining 2% other but not detailing any particulars.

The following contents were identified on the Understanding of Robotics Fundamentals: I understand the basic components of a robot (e.g., sensors, actuators, controllers), I can explain the difference between autonomous and semi-autonomous robots., I am familiar with the basic concepts of robotic kinematics (e.g., forward and inverse kinematics), Programming and Control: I am proficient in programming robots using languages such as Python, C++, or Java., I understand the principles of robot control systems (e.g., PID control)., I can write simple programs to control robotic movements and behaviors., Mechanical Design and Assembly: I understand the principles of mechanical design in robotics (e.g., gears, linkages)., I have experience with assembling basic robotic structures and mechanisms., I am familiar with the use of CAD software for designing robotic parts., Sensors and Actuators: I understand how different types of sensors (e.g., ultrasonic, infrared, touch) are used in robotics., I can integrate and configure various actuators (e.g., motors, servos) in a robotic system. , I am familiar with the concept of sensor fusion and its importance in robotics., Robotics Applications and Ethics: I can identify different applications of robotics in industries such as manufacturing, healthcare, and entertainment., I understand the ethical considerations involved in the deployment of robotic systems., I am aware of the impact of robotics on society and the future of work?.

While in the context of General Understanding of Industry 4.0: I understand the fundamental principles of Industry 4.0 ., I can explain the significance of Industry 4.0 in modern manufacturing., I am aware of the key technologies

driving Industry 4.0 (e.g., IoT, AI, big data). , Internet of Things (IoT): I understand how IoT devices communicate and interact in an Industry 4.0 environment., I am familiar with the applications of IoT in manufacturing and industrial settings., I can describe the role of IoT in predictive maintenance and smart manufacturing., Artificial Intelligence (AI) and Machine Learning (ML): I understand the basics of AI and ML and their applications in Industry 4.0 ., I can identify how AI and ML are used to optimize manufacturing processes., I am aware of the benefits and challenges of integrating AI and ML in industrial operations., Big Data and Analytics: I understand the concept of big data and its relevance to Industry 4.0., I can explain how data analytics can improve decision-making in manufacturing., I am familiar with the tools and techniques used for big data analysis in an industrial context., Automation and Robotics: I understand the importance of automation in Industry 4.0 ., I am familiar with the role of robotics in smart factories., I can explain how automation and robotics contribute to increased productivity and efficiency., Smart Factories and Digital Twins: I understand the concept of smart factories and their characteristics., I can explain what digital twins are and their applications in Industry 4.0., I am aware of the benefits of implementing digital twins in manufacturing processes., Ethics and Workforce Impact: I understand the ethical considerations related to the adoption of Industry 4.0 technologies., I am aware of the potential impact of Industry 4.0 on the workforce and employment., I can discuss the importance of upskilling and reskilling workers for Industry 4.0.

These are the initial results in the

1. Evaluation of the 21st Century Skills Program's Curriculum Integration: Examine how ITRED's 21st Century Skills Program blends communication, teamwork, creativity, and critical thinking into its lesson plans and instructional strategies. This entails assessing how well the curriculum complies with international standards for 21st-century learning. (OECD European Commission, 2019).
2. Analyze Student Competency Development: To find out how much the ITRED program's participants' students are developing the skills needed for Industry 4.0. This covers both the hard skills needed for robots and information technology as well as the soft skills necessary for today's workforce.

6. Limitations

1. Limitations such as the sample size and diversity, the study was restricted to a particular batch of Quezon City students, which might not accurately reflect the larger student population in other places. The findings may also be less broadly applicable due to the relatively small sample size.
2. Due to its narrow geographic focus, the study may have missed regional differences in educational resources, industrial demands, and socioeconomic factors that could have an impact on the ITRED program's efficacy. The study only included students from Quezon City.
3. Throughout the investigation, the study depended on participant self-reported data, which is prone to biases such social desirability bias or erroneous self-evaluation. The authenticity and dependability of the data that was gathered may be impacted by this.
4. It is difficult to assign observed outcomes exclusively to the ITRED program in the absence of a control group comprised of students who are not enrolled in the program. The students' acquisition of 21st-century capabilities might have been impacted by additional outside variables.
5. The method of measuring 21st-century capabilities involved certain instruments and techniques, which might not have fully captured the range of these abilities. A more thorough understanding might be possible with different assessment techniques or more qualitative data.
6. Study could not account for the numerous extrinsic variables, including parental participation, extracurricular activities, and access to technology outside of the program. These elements might have influenced the outcome.

7. Recommendations

1. Student outcomes may vary depending on how differently the ITRED program was administered in different classrooms or schools due to program implementation variability, which was not taken into consideration.
2. Understanding the scope and background of the study is made simpler by acknowledging these limitations. Even though the study seeks to provide insightful information about the effects of the ITRED program, acknowledging and resolving these limitations is essential to correctly understanding the findings and directing future research.
3. Further investigation will be needed in several areas, nevertheless, in order to close the remaining gaps and advance the conclusions. The following important areas—like the Long-Term Impact Assessment—need further research. Short-term results and the program's immediate effects may be the main subjects of the study. Determine how the ITRED program will affect students' ability to advance in their careers, prepare them for the workforce, and retain their skills over a number of years.
4. It is suggested that future studies look into things like how students who took part in the ITRED program fare more or less in the labor market than those who did not. What are the career outcomes and long-term skills that can be linked to involvement in the ITRED program?
5. Without evaluating ITRED's program against others of a similar nature, the study concentrates on it. Perform comparison analyses to assess ITRED's program's effectiveness in relation to comparable 21st-century skills initiatives in other nations or areas. Regarding potential future study topics, such as how the ITRED program's efficacy and results compare to those of other programs of a similar nature? What other effective programs' best practices exist that ITRED's program could incorporate?
6. Variations in program implementation may affect outcomes, but these variations may not be fully explored, and investigate how different aspects of program implementation (e.g., duration, teaching methods) influence the effectiveness of the ITRED program with future research questions like, what are the effects of different program components (e.g., hands-on projects, mentorship) on student outcomes? How do variations in program delivery affect the overall effectiveness and student satisfaction?

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