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Preface

This volume contains papers presented at the 2019 International Conference on Mathematics, Science and Technology Teaching and Learning (ICMSTTL 2019), which was held in Central Queensland University Australia - Sydney Campus, Australia during June 28-30, 2019.

The conference was sponsored by University of Central Queensland and co-sponsored by University of New South Wales, University of Technology Sydney, and Tsinghua University in Taiwan. The theme is "Learning and Teaching Mathematics, Science and Technology in the Digital Age: Eyes on the Stars; Feet on the Ground"

The conference attracted experts, scholars, research students, and teachers from primary to tertiary education sectors from fourteen countries or districts in the world. All papers included in this volume were peer-reviewed by at least two referees in their disciplines. We sincerely thank all the authors for their contributions to the conference and would like to extend our gratitude to the reviewers for volunteering their time to provide constructive feedback and hence to ensure the quality of papers included in this volume.

On behalf of the Organizing Committee, we are grateful for the excellent services provided by all committee members, session chairs, administrative officers, and volunteers during or throughout the conference. The generous support to this conference from the Associate Vice-Chancellor and Office of CQU-NSW and the School of Engineering and Technology at CQU made this event possible and successful, which is greatly appreciated.

We look forward to your support to and participation in future events of ICMSTTL.

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Improving Learning through Cloud-based Mobile Technologies and Virtual and Augmented Reality for Australian Higher Education

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ABSTRACT
Latest technological innovations like Cloud-based mobile technologies and virtual and Augmented Reality (AR) have the ability to create great learning experiences. However, few researches exist regarding how AR can be utilized and integrated to complement learning. Currently, the existing research focuses on integrating AR in classes to aid students but few dwells on integrating AR in online learning platforms applications. The increased use of mobile devices has allowed the introduction of online learning management systems that allow people to access e-books, papers, and articles online. As technological inventions continue to emerge, there is a need to investigate and internalize how these new technologies can complement learning. In this research, we investigate how the integration of VR and AR and Cloud-based mobile technologies can improve learning in Australian Higher Education. We conduct a survey to determine how the integration of AR and artificial in the Moodle learning management system can impact the user experiences. We then discuss the current development in virtual and AR and Cloud-based mobile technologies in the education system through a literature review. Our preliminary analysis shows that integration of AR and artificial intelligence may lead to better learning experiences.

CCS Concepts
•Applied computing→Education→E-learning •Applied computing→Education→Computer-assisted instruction • Applied computing → Education→Learning management systems

Keywords
Augmented Reality; Virtual Reality; Artificial Intelligence; Mobile Cloud computing.

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1. INTRODUCTION
In today's organisation the new technologies need to be adopted in order to minimized internal and external pressure [1]. The use of Cloud-based system in education is still an emerging issue when it comes to sharing of learning issues on the internet. There are various ways that education and skills can have an impact on people. Technology has transformed the teaching methods from just books and classrooms to use of computers, e-learning and online classes. The modern pedagogy stakeholders propose that the education sector needs to be transformed to accommodate the diverse needs of modern society. As a result, technological evolution in the education sector have led to emergence of Learning Management Systems (LMS) like Moodle, ATutor, Eliademy and OpenOLAT, among others. Apart from the LMSs, eLearning platforms like Udemy, Teachable, WizIQ, Ruzuku and SkillShare, among others, offer online courses to many learners[2]. The LMS and eLearning platforms have a major benefit in that they bring together experts who offer online courses, eBooks and learning materials to thousands of students online. According to the National Centre for Education Statistics, around 5.9 million students were enrolled in post-graduate distance learning in fall 2015[3]. Currently, people access these education resources through their mobile devices and computer browsers. The majority of these platforms have not introduced 3D or AR technologies. Therefore, Handheld AR and VR can be introduced in these platforms to enhance the learning experience.

1.1 Research Objectives
The main aim of this study is to establish whether Cloud-based mobile technologies and Virtual and augmented reality improves learning for Australian Higher education. The specific objectives are;

- To determine whether interactive mobile learning platform improves learning among Higher education students in Australia.
- To establish if Virtual and augmented reality enhances learning and teaching for Australian Higher education.

1.2 Research Questions
This study is guided by the following research questions;

1. Does interactive mobile learning platform improve learning among Higher education students?
2. Do Virtual and Augmented reality and Artificial intelligence enhance the learning and teaching?

2. LITERATURE REVIEW

Cloud computing (CC) is an Internet-centric computing service that utilises and provides IT services to organisations through the provisioning of resources through the Internet using web-centric software and gadgets without the assistance of any private IT architecture within the firm [4]. Cloud based interactive mobile learning platform is the result of such exploration and this practice of learning is improving with time. New technologies such as smart mobile devices, CC and wireless connectivity are opening new opportunities of learning for higher education students Augmented Reality (AR) enables virtual imagery generated by computers to be relayed in real-time onto a real-world environment[5]. AR and VR perform the same functionalities but in VR, the virtual environments experienced by people are computer generated while in AR, people experience virtual environments generated from real environments. The first AR and VR system was developed in 1960 [6]. To experience the virtual environment, users utilized a head mounted optical display. However, AR and VR did not evolve faster due to limitation of computer processing power. Major corporations have however been utilizing AR for training and visualization purposes[7]. AR systems work on either marker-based or marker-less based. Marker-based applications are composed of a booklet that offers marker information, a gripper for relaying information to the marker and a cube that augments the supplied data into 3D for screen display. Markerless-based augmented reality applications comprises a Global Positioning System (GPS), a compass, and an image recognition system. Siriborvornratanakul[8], observes that markerless-based AR applications have broader applicability compared to marker-based applications.

According to Sandu[9], integration of AR and VR into the education system can boost learners' interest in education. He further argues that adoption of VR and AR technology in the education sector will enhance learning, increase students' memory capacity and enable learners to make better decisions. Currently, experts have proposed the application of AR and VR in teaching subjects like chemistry, mathematics and physics, among other subjects[10]. Augmented astronomy is an area that has been explored in schools where 3D rendered imagery simulation of the galaxy is used to teach students about the solar system [11]. Papanastasiou[5], describes the Google SkyMap as an AR centered application that overlays images and information about the stars and planets. The SkyMap application allows students to browse the sky using a camera or a smart phone. Augmented biology is another area that has been explored in higher education. VR and AR helps students in understanding the anatomy of the human body[12]. The Specialist Schools and Academies Trust (SSAT) formulated an experiment to illustrate how teachers could use AR and VR to simulate the body's organs by using computers to generate 3D models [2]. Chen observes that students can use these applications on their laptops or mobile phones to study on their own. Despite the increased research on how AR and VR can be integrated in the education system, few challenges are still hampering its uptake. First, there is complexity in integrating these technologies with the traditional learning methods, the cost of developing and maintaining the applications is high, and there is less cooperation from the relevant authorities [11].

Siriborvornratanakul[8], discusses an application called SMART; an Education System of augmented reality for teaching students using AR technology. This technology utilizes AR to teach 2nd grade concepts such as modes of transportation and types of animals. The system has 3D models and prototypes for animals, vehicles and airplanes on real time videos in classes. Game-based learning is viewed as a good way to teach kids since they spend a lot of time playing video games. According to research conducted by Siriborvornratanakul on 54 students in Portugal, the SMART system helped to boost students' motivation and positively impacted the less academically enabled kids. Application of VR and AR in colleges and universities is believed to enhance students' skills, especially in difficult theories and system models. Research indicates that integration of AR and VR in teaching complex theories and simulation of system models has increased the level of acceptance, enthusiasm and understanding among the students.

In 2001, researchers indicated that the integration of VR and AR in books can make them interactive and realistic[13]. Further research indicates that young people are more interested in reading materials that are realistic and interactive. Use of AR and VR to include 3D models in books creates a "Magic Book" that allows the readers to become part of the story. Pellas[14], indicated that a normal book can be transformed into a "magic book" by installing an AR/VR tool kit software and then using their computer or smart phone cameras to view the computer generated 3D models.

3. RESEARCH METHODOLOGY

This study employed an experimental research design by conducting a survey questionnaire. The study population comprised of all students pursuing higher education using Cloud service delivery systems in Australia. A sample of 51 students pursuing different courses at an institution of higher learning was selected. The Moodle Mobile app was used as a learning platform for the research. The study capitalized on user feedback from the Mobile app. Stratified random sampling was used in sample selection. Data collection was conducted using survey questionnaires available on the mobile apps feedback. The questionnaires comprised of 9 questions divided into three sections; basic information on gender and age of the respondent as well as their rating of the application; the experience of using the Moodle app, which included problems and issues encountered in using the app, ease of use and the experience of using the learning platform for studies; and their opinion on the use of Artificial intelligence and Virtual and Augmented reality in making learning more effective and efficient.

4. DATA ANALYSIS AND RESULTS

Data was imported into SPSS for analysis. Initially, data was cleaned and validated to ensure that relevant information was used for analysis. Descriptive statistics and inferential statistics were then conducted. To answer the research questions, frequency tables, charts and measures of dispersion were used.

To ensure reliability, the feedback questionnaire was first pretested on students and the results subjected to Cronbach's alpha, yielding a significant average coefficient of 0.8 as shown in Table 1, demonstrating sufficient reliability. Data collected on the mobile platform was imported into Statistical Package for Social Scientists (SPSS) for analysis.

Table 1. Cronbach's alpha test

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.889	.908	17

4.1 Descriptive Statistics

The data that was obtained also showed that the younger generation was mostly considered since the technology of Cloud computing is a new technology that could be effectively implemented by the younger generation [2]. Descriptive results from the study indicates that 29 (56.9%) males and 22 (43.1%) females were used. It can be concluded that both genders are well represented in the study as shown in Figure 1.

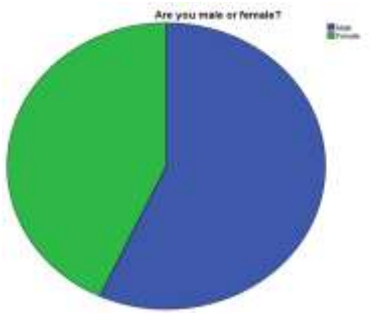

Figure 1: The gender of the respondents

Additionally, on the ratings of the Moodle app by users, 38.8% of users gave a rating of 4 forming the majority, while 34.7% gave a rating of 5. Average ratings were 3.97 (SD= .915). Noteworthy is the fact that there was no 2-star rating.

This indicates that the app is highly rated by the majority of users as shown in Table 2.

Table 2. The rating of Moodle app

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.0	2.0	2.0
	3	12	23.5	24.5	26.5
	4	19	37.3	38.8	65.3
	5	17	33.3	34.7	100.0
	Total	49	96.1	100.0	
Missing	System	2	3.9		
Total		**51**	**100.0**		

The majority of the respondents were aged between 18 and 24 years, constituting 58.8% of respondents, as indicated in table 3. This was followed by individuals aged 25-34 years with 37.3% as shown in Table 3.

Table 3: The age category of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	30	58.8	58.8	58.8
	25-34	19	37.3	37.3	96.1
	35-44	2	3.9	3.9	100.0
	Total	**51**	**100.0**	**100.0**	

On the user experience, the majority of the respondents (26%) felt that the app was confusing to use. They further suggested that the app was missing features needed by 24%, and 22% indicated that the app was visually unappealing. Apart from that, 21% of users gave other reasons, such as the app needing more testing, and a responsive design needing to be adopted for mobile device. Few users also expressed concerns with security and frequent crashing of the application. This is shown in Figure 2.

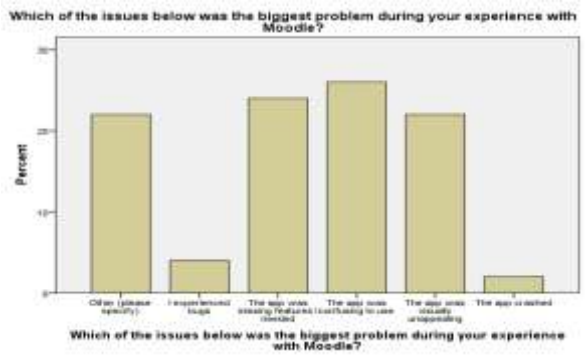

Figure 2: The biggest problems experienced during the use of the app

On the features, functionality of the app was most liked by the users with a percentage of 29.2, followed by the content with 22.9%. Navigation and stability had 16.7% and 14.7% respectively as indicated in Table 4.

Table 4: The most liked feature of the app

	Frequency	Valid Percent	Cumulative Percent
Other (please specify)	1	2.1	2.1
Navigation	8	16.7	18.8
Functionality	14	29.2	47.9
Look and feel	3	6.3	54.2
Speed	4	8.3	62.5
Stability	7	14.6	77.1
Content	11	22.9	100.0
Total	**48**	**100.0**	

4.1.1 Research Question 1: Interactive Mobile Learning Platform Improve Learning

To answer the research question on whether an interactive mobile learning platform improves learning among Higher education students in Australia, descriptive statistics have been used. The Moodle Mobile app was used as a learning platform for the research. The ease of use of the platform was evaluated. Table 5 shows that 54.8% of the users agreed that the app was easy to use while 26.2% somewhat agreed. 11.9% strongly agreed that the app is easy to use as seen in Table 5.

Table 5: The app's ease of use

	Frequency	Valid Percent	Cumulative Percent
Strongly agree	5	11.9	11.9
Agree	23	54.8	66.7
Somewhat Agree	11	26.2	92.9
Neither Agree nor Disagree	3	7.1	100.0
Total	**42**	**100.0**	

4.1.2 Research Question 2: Effect of Virtual and Augmented Reality and Artificial Intelligence in Enhancing Learning and Teaching

To answer the research question on whether Virtual and Augmented reality and Artificial intelligence has enhanced learning and teaching, descriptive frequency data in table is used. Table 6 shows that a majority (50%) of the users strongly agreed that the use of Artificial intelligence and Virtual and Augmented reality can make learning more efficient and effective.

Table 6: The responses for "Do you believe the use of Virtual and Augmented reality and Artificial Intelligence can make learning more efficient and effective"

	Frequency	Valid Percent	Cumulative Percent
Agree or Strongly Agree	21	50.0	50.0
Neither agree nor disagree	14	33.3	83.3
Disagree	1	2.4	85.7
Strongly disagree	6	14.3	100.0
Total	**42**	**100.0**	

Additionally, 33.3% neither agreed nor disagreed, 2.4% disagreed and 14.3% strongly disagreed. This implies that the use of Artificial intelligence and Virtual and Augmented reality to make learning more efficient and effective is supported by the majority of respondents. Security and privacy are also one of the major concerns for many students. Similar to studies conducted by Robinson[15], the reasons stated by many students was security concerns over using a network and privacy issues with fear of losing sensitive data. Providing robust security and privacy for any web-based application is challenging, however when using Cloud based systems, these challenges become even more difficult to address.

5. DISCUSSION AND CONCLUSION

From the foregoing results, this study established that the majority of the respondents were male and were aged between 18 and 24 years. Further, regarding the user experience, the majority of the respondents indicated that the app was confusing to use. On the features, functionality of the app was most liked by the users. Additionally, the majority of users showed that ease of information access was enabled.

To answer the research question on whether an interactive mobile learning platform improves learning among Higher education students in Australia, descriptive statistics have been used. The Moodle Mobile app was used as a learning platform for the research. The ease of use of the platform was evaluated. Results shows that a majority of the users agreed that the app was easy to use. Additionally, a majority of users agreed that they were able to use the app without instructions. It is established that the majority of users were in agreement regarding the cohesiveness of the app's pages/sections in look and feel.

On the research question on whether Virtual reality and Artificial intelligence has enhanced learning and teaching, results show that a majority of the users strongly agreed that the use of Artificial intelligence and Virtual reality can make learning more efficient and effective. This implies that the use of Artificial intelligence and Virtual reality to make learning more efficient and effective is supported by the majority of the respondents

In conclusion, it is evident that the use of Cloud-based mobile technologies and Virtual and augmented reality improves learning for Australian Higher education. This is validated by the positive feedback from Moodle Mobile application users.

6. FUTURE STUDIES

The current Augmented Reality (AR) and Virtual Reality (VR) inventions are mostly centered on industrial and business use. Lack of enough resources still make the application of VR and AR at the mercy of big industrial players. A comprehensive approach needs to be adopted on how there can be increased use of AR and VR in all education levels. One major area of study is how artificial intelligence can be coupled with AR and VR to help students. As the need for comprehensive research increases, the use of these technologies in the education system can boost the level and quality of education and teachers. The research data was only collected from an Australian education institute. The research should be sent to more institutions to generalize findings in Australia. Future studies should be conducted using both qualitative and quantitative forms of study to uncover more factors from multiple perspectives.

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Android and FIREBASE mBaaS-based Information System Design of Students Activity Unit (SAU) Using the Rational Unified Process (RUP) Method

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ABSTRACT
The study is aimed at developing an information system for the Students Activity Unit (SAU) of the Reasoning Division based on the Android and mobile Backend as a Service mBaaS and finding out the quality of the system on the aspects of functional suitability, compatibility, usability, and performance efficiency on the ISO 25010 criteria. The study was a research and development (R&D) project. For the research method, the study used the rational unified process RUP model for software development. The developed information system satisfied the ISO 25010 quality standard for all the required criteria. On the function suitability aspect, the system reached 100% percentage fulfilling the AQuA quality standard; on the compatibility aspect 89.99%; and on the usablity aspect 82.83% ("highly feasible"). On the performance efficiency aspect the system showed a response average of 3.46 seconds ("highly satisfying").

CCS Concepts
• **Information systems→ Information systems applications**

Keywords
Keywords information system; Android; mBaaS; RUP; SAU.

1. INTRODUCTION
Yogyakarta State University (YSU) attempts to realize its vision to become a world-class education university in 2025 based on piety, autonomy, and wisdom. The year 2017 marked the struggle of YSU in educating students for 53 years. During this year, a large number of achievements were made by students. These achievements were not spontaneous; buy they were obtained by the struggles and supports of many parties.

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In lieu with the visions of YSU, the development of students with piety, autonomy, and wisdom has been done via various structured and systematic programs. Up to the present time, YSU has been committed to elevate students' achievements through systematically-programmed activities. Achievement is one of the parameters for the success of student development. This is in view of the awareness that one of the primary assets of global competitiveness is the existence of quality students as excellent forerunners of the nation. In order to produce high-achieving students, developmental programs are required to improve students' soft skills and hard skills by way of developmental facilities for talents, interests and motivations in the faculty and study-program levels. Collaboration and synergy among various parties in the university are efforts to guide and advocate students.

Students Activity Units (SAU) are activity venues for students who have the same interests, hobbies, creativities and orientations for facilitating extracurricular programs in campus. In reality, a great number of students put their focus merely on the academic matters, despite the wide opportunity to develop their non-academic capacities. This is due to the low interest and willingness to join SAUs. The minimal detailed information about SAU affects the students' interests to join an SAU. Although an SAU display has been given during the new student orientation program, very little has been known about the activities and achievements of the SAUs.

On the other side, technological advancement has run in great speed especially in the digital technology as a result of the use of the smartphone. Rapid advancement of technology doubled with the high support of contents has made the transformation of the media paradigms from the conventional to the digital through the Internet. Users of the digital technology through the smartphone operated by the Android in Indonesia have multiplied greatly.

According to a MoboMarket study in 2015, there were 3.13 million active users of the Android smartphone in Indonesia; 67.34% of which were in big cities, including Yogyakarta, , and 73% were teenagers (Baidu, 2015). Concerning the use of digital media information, a study by the Indonesian Association of Internet Providers (APJII, 2015: 20) reported 88.1 million of active Internet users in Indonesia

Backend as a Services (BaaS) is one of the cloud computing service categories provided by a company to help mobile application developers to build, use, and operate backend clouds

for the developed applications. BaaS helps developers by linking their applications to backend cloud databases and features such as user management, push notification, and integration with social networking services. These services generally are provided with the support of Software Development Kits (SDK) and Application Programming Interface (API).

In view of the foregoing background description, in order to grow students' interest and motivation to join SAU activities, an information system was developed in SAU of the reasoning division based on the Android and Firebase mBaaS using the Rational Unified Process (RUP) method.

1.1 Information System

A is an important element that an institution must have in order to support its work function. This is because work can proceed well if there are cooperation among the components of the system. A system is a unity of components working together to achieve a determined objective (Sutopo, 2012: 85). Meanwhile, information is result of analysis and synthesis upon data. In others words, information can be said as data that have been organized in a way that suits an individual's needs (Kadir, 2008: 7).

An information system is a group of sub-systems that are interrelated, coordinated, forming a unity, and interacting and cooperating among each other to manage data, receive inputs in the form of data, and produce outputs in the form of information to be used as a basis for decision making. The decision must be functional and have real values of which the consequences can be felt at the present or in the future in order to support operational, managerial, and organizational activities making use of the available human resources to achieve the determined objectives (Sutanta, 2011: 14). According to Haryanto (2008), an information system in an organization is one that consists a combination of personnel, media, facilities, technology, procedure, and control of the communication network to process a certain transaction to give signals to the management and others concerning an event and provide informational bases for decision making. In another sense, an information system is a formation of physical components such as hardware, software, data bases, procedure, and persons working together to produce information as a basis for decision making. Indicators for a quality system or software are where designed plans fulfill the functions and features specified by needs models (Pressman, 2012: 484). Furthermore, Robert Glass argues that quality is important, but it is consumers' satisfaction is primary.

1.2 Students Activity Unit of the Reasoning Division

Students Activity Units (SAU) is a venue of extracurricular activities for university students in reasoning, talents, interests, hobbies, student welfare, and community services (Sukirman, 2004: 72). The SAU is one of the students' organizations for the development the students to expand perspectives and elevate soft skills.

A study in Harvard University, USA, it is found that one's success is not only determined by students' technical skills (hard skills). Instead, a major criterion for success is the ability to manage one's self and others (soft skills). More specifically, one's success is determined 80% by one's soft skills and 20% hard skills.

A student's soft skills are believed to be able to form a generation that is competitive, ethical, decent, and able to interact with the community (Wibowo, 2014: 53). Furthermore, inability to give soft skill education is likely to produce graduates who are good at memorizing but are incompetent in the world of work. A soft skill is one that enables students to think analytically and developmentally, have logical and critical thinking, be able to work together in a team, and do and behave well in working leading to autonomy (Wibowo, 2014: 56). A soft skill is a non-academic competency as a capital for one to be successful in one's career and function well in the society's life.

The SAU is an activity venue for students to develop their talents, interests, hobbies, creativities, and moral virtues (Paidi, et al, 2012: 240). In Verse 4 of the Educational Laws Number 13 Year 2012, it is stated that higher education functions to develop and form the characters and civilization of the nation in the frame of intellectualizing the nation's life. Meanwhile, in Verse 5, there are higher education goals, among others:

1. Development of students' potentials to be persons who are faithful to God, decently behaving, healthy, scientific, smart, creative, autonomous, skillful, competent, and cultured for the sake of the nation.
2. Generation of graduates who master the field of science and/or technology to fulfill the nation's needs and elevate the nation's competitiveness.

The SAU is an adjunct to the curricular programs in the university in the form of non-academic activities carried out independently by the students. The university, the place for producing quality human-resources generations, must be able to accommodate students' creativities to develop their potentials, talents and interests, and soft skills. In the 2002 Educational Laws Number 12, Verse 13 states that students are entitled to educational services in accordance with their talents, interests, potentials, and skills. In the same legal document, Verse 14 states that:

a. Students develop their talents, interests, and competencies by way of co-curricular and extracurricular as part of their educational processes.
b. Co-curricular and extracurricular activities, as mentioned in Item 1, can be carried out by students' organizations.

The SAU is a place for students with the same talents, interests, hobbies, creativities, and orientations as their extracurricular activities at campus. In fact, many students exercise their rights for the academic programs whereas opportunities for extracurricular activities are quite wide. This is because students have minimal interest and willingness to take SAU activities. Meanwhile, the SAU provides students with more learning and experiences; no only in the academic fields but also in talents, interest, potentials, and organizational skills in order to make excellent achievements. This way, there will balance in students' achievements. Education is, in fact, not only giving academic knowledge and skills but also development for their actual potentials.

Provision of students' activities in reasoning is meant to elevate students' achievements and soft skills, particularly in the field of scientific communication either directly or indirectly via print and electronic media. This field of development is focused on comprehensive and systemic thinking. Therefore, this reasoning skill becomes appropriate way for students to think and prepare themselves to become persons with academic perspectives. The SAU of the Reasoning Division consists of SAU for Research, SAU for "EKSPRESI" Students Press, SAU for Radio Magenta,

SAU for "SAFEL" Foreign Language Learning, and SAU for "RESTEK" Technological Engineering.

1.3 Mobile Backend as a Service (mBaaS)

Cloud computing has developed rapidly in the last three years. Presently, cloud computing has encroached mobile communication. Users of informational technology have changed from hardware orientation to service orientation by the variety of services offered by cloud computing. These services include Infrastructure as a Service (IaaS), Platform as a Service (Paas) and Software as a Service (SaaS). The combination of IaaS, PaaS, and SaaS has had a great impact on the development of mobile communication.

Mobile Backend as a Service (mBaaS) is a service of cloud computing that enables one mobile application developer to make an integration among database, cloud storage, push notification, management user, application program interface (API), and software development kit (SDK). A wide variety of integration endorsement is provided by mBaaS on many platforms. Ease in the management user database, file management, social networking integration, location services, and load balancer of traffics entering the mobile applications is also one convenience offered by mBaaS.

Firebase is one provider of mBaaS. Firebase has experienced great changes since May 2016 with its Firebase 3.0. Version. Compared with the previous versions, that are limited to authentication service and real-time database, Firebase 3.0. offers far more complete services. Presently, Firebase 3.0. has at least 15 services as can be seen in Figure 2.

Figure 1. Firebase service (http://firebase.com)

Firebase gives services for Service Develop at the time of the application development in the form of (1) Realtime Database, (2) Authentication, (3) Cloud Messaging, (4) Storage, (5) Hosting, (6) Test Lab, (7) Crash Reporting, and (7) Cloud Functions. Other than the services for application developers for end users, Firebase 3.0 also gives services in the form of (1) Notification, (2) Remote Config, (3) App Indexing, (4) Dynamic Link, (5) Invites, and (7) Adword.

Firebase 3.0 also provides services for various merchants to advertise products by AdMob services. One Data Analytics service is also offered by Firebase 3.0. in line with the trend of Big Data at the present time.

1.4 Android

The Android is a system used by Linux-based mobile sets that includes operating system, middleware, and application. The Android is an open source so that anybody can take part in developing the system. In the initial phase, the Android was developed by a company by name of Android Inc. In the process, Google bought Android Inc. as a new comer in software for the cellphone/smart phone. In the early development of the Android, an Open Handset Alliance was developed as a consortium forum of 34 companies in hardware, software, and telecommunication including Google, HTC, Intel, Motorola, Qualcomm, T-Mobile, and Nvidia.

Figure 2. Architecture of the Android (http://developer.android.com)

The Android is marked with four characteristics of (1) open, (2) all application (3) solving obstacles in applications, and (4) having many libraries and supporting tools. In general, the architecture of the Android is built of (1) Application (2) Application Framework (3) Libraries (4) Android Runtime and (5) Linux Kernel. The components that become the bases for the Android are, among others: (1) Activities (2) Services (3) Content providers and (4) Broadcast receivers.

2. RESULTS AND DISCUSSION

2.1 Inception

Inception is a phase in a business process modeling in line with the perceived needs and in defining users' needs that will be developed. The development of the system is firstly done through the needs analysis phase for functional needs. The functional needs analysis includes primary functions that are later needed in the application. Based on the observation and interview, the obtained functions are:

1. User can know the profile of the SAU of the Reasoning Division
2. User can read news related to the SAU of the Reasoning Division
3. User can look at the gallery of activities of the SAU of the Reasoning Division
4. User can see the achievements of the SAU of the Reasoning Division

2.2 Elaboration

2.2.1 Software

Software that is used to operate an application must have a minimal number of criteria as shown in Tabel 1. Software needs are at least linked to the use of the resources library that is used in the system development process. There are some minimum requirements determined by the resources library in the system development. The system development is done by use of Android Studio 3.1.3 on the OSX Sierra operating system.

Table 1. Software specification

Component	Minimal Specification	Recommendation Specification
Operating system	Lollipop	Oreo
Version	5.0	8.1

2.2.2 Hardware

Two kinds of hardware were used in this study. The first, the hardware used to develop the system, was a notebook of the specification Macbook Pro 13 inch Late 2011 Processor 2.8GHz Core i7, Memory 16G, Storage SSD 256G, and Storage data 500G. The second, the hardware used to run the system, was an Android-based smartphone HTC 10 of the specification Processor Quad-core (2x2.15 GHz Kryo & 2x1.6 GHz Kryo), GPU Adreno 530, Chipset Qualcomm MSM8996 Snapdragon820, Memory 4G RAM, Internal Storage 32GB, Monitor screen 5.2 inch, and External storage 32GB.

2.2.3 System design

Figure 3. Block System Diagram

The Android-based information system of the SAU of the Reasoning Division consists of four sections of (1) User application, (2) Administrator, (3) mBaaS, and (4) Presma. In the application side, users utilize the information system developed and installed in an Android-based Pada smartphone berbasis android. This application can be accessed simultaneously with no limitation. This makes it easier to look at data that are displayed online. The administrator is one application but functions to upload news and galleries. Meanwhile, achievements are uploaded separately using the Presma system. The SAU information system will access Presma data directly on the Presma system http://presma.uny.ac.id and display information according to each category of (1) Reasoning, (2) Sports, (3) Arts, or (4) Special interest. Firebase, as a cloud-based place to save data, can be used to save data in the forms of texts or pictures. The complete news will be saved in realtime database and pictures in storage. The gallery is saved in storage

2.3 Construction

2.3.1 Development of the application

The SAU information system is built on the software Integrated Development Environment (IDE) Android Studio 3.1.3 using the Java programming language. The Android Studio is a software for developing a smartphone-based application development by using Android. The program structure in the Android is activity-based and the layout is an XML file.

2.3.2 mBaaS configuration

The realtime database services function as data saving for information data bases both for SAU profile and SAU news. Realtime database in firebase has the data structure of the JSON (Java Script Object Notation) format as is shown in Figure 5. The database structure uses the tree-diagram concept. Besides using the realtime database, the system also uses the storage service for file saving (Fig 4-5).

Figure 4. Firebase realtime database

Figure 5. Firebase storage

2.3.3 Code writing

The system uses the IDE Android Studio 3.1.4 in Java programming language. There are some activities and fragments in the application. For Activity, the activities are SplashActivity, MainActivity, AuthAdminActivity, AdminActivity, DetalNewsActivity, GaleryDetailActivity, and SearchPresmaActivity. For Fragment, there are news fragments and gallery fragments (Fig-6-8).

Figure 6. System display news

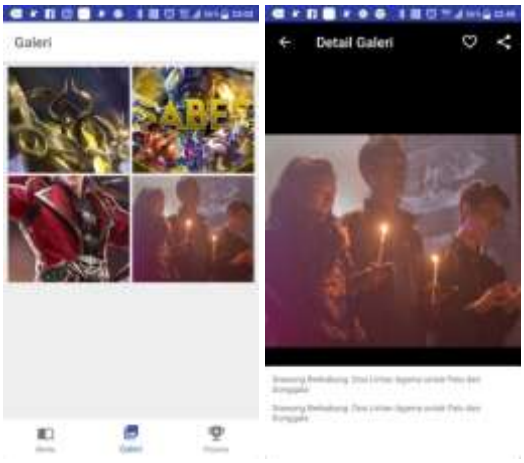

Figure 7. System display gallery

Figure 8. System display achiement and search

2.4 Transition

2.4.1 Functionality

Assessment was done using the test-case sheet testing the application on six experts in mobile development working in leading software companies in Indonesia. Respondent data can be seen in Table 2, point 1 is representation of success test and zero for failed test. Based on the results of the percentage counts, the functional suitability measure can be seen as follows:

$$Yes = \frac{162}{162} \times 100\% = 100\%$$

$$No = \frac{0}{162} \times 100\% = 0\%$$

2.4.2 Compatibility

The testing of compatibility is a measurement technique to see whether the Android-based information system can be operated on different hardware with different specifications. Google play has a compatibility test service for an application with different device specifications (hardware and software android versions) worldwide. Feasibility measure from Google Play shows that there are 9,742 devices that support the SAU information system out of the10.826 listed in Google Play (Fig-9). It can therefore be found that the system has compatibility at the measure of 89.99%.

Table 2. Results of test-case respondent

No	Activity Test	Respondent					
		A	B	C	D	E	F
1	Opening Application	1	1	1	1	1	1
2	Splashscreen page	1	1	1	1	1	1
3	Beranda Navigasi News	1	1	1	1	1	1
4	List News Page	1	1	1	1	1	1
5	Detailed News Page	1	1	1	1	1	1
6	Bottom ©Navigasi Galery	1	1	1	1	1	1
7	List Gallery Page	1	1	1	1	1	1
8	Detail Gallery Page	1	1	1	1	1	1
9	Bottom Navigation Achievement	1	1	1	1	1	1
10	Home Navigation Reasoning Achievement	1	1	1	1	1	1
12	Search page Reasoning Achievement	1	1	1	1	1	1
13	Share Reasoning Achievement detailed information	1	1	1	1	1	1
14	Bottom Navigation Art Achievement	1	1	1	1	1	1
15	Search page Art Achievement	1	1	1	1	1	1
16	Share Art Achievement detailed information	1	1	1	1	1	1
17	Bottom Navigation Special Interest Achievement	1	1	1	1	1	1
18	Search page Special Interest Achievement	1	1	1	1	1	1
19	Share Special Interest Achievement detailed information	1	1	1	1	1	1
20	Bottom Navigation Sport Achievement	1	1	1	1	1	1
21	Search page Sport Achievement	1	1	1	1	1	1
22	Share Sport Achievement detail information	1	1	1	1	1	1
23	Authentication Administrator	1	1	1	1	1	1
24	Post News Page	1	1	1	1	1	1
25	Select Picture in Post News page	1	1	1	1	1	1
26	Post Gallery Page	1	1	1	1	1	1
27	Select Picture in Post Gallery page	1	1	1	1	1	1

$$Compatibility = \frac{9742}{10826} \times 100\% = 89.99\%$$

Figure 9. Google play support device

2.4.3 Usability

Assessment of the usability aspects of the system was done on the management personnel of the SAU branches (Research, Restek, Magenta, Safel and Ekspresi) of 20 people. The usability testing instrument was the USE Questionnaire which consists of 30 questions. Results of the testing can be seen in (Table-3).

$$Percentage = \frac{2485}{3000} \times 100\% = 82.83\%$$

Table 3. Results of Usability Testing

Converted Scale	Total	Score	Score Total
Highly agree	145	5	725
Agree	400	4	1600
Doubtful	50	3	150
Disagree	5	2	10
Highly disagree	0	1	0
Total Score			2485
Maximum Score			3000

The results were subsequently subjected to the score conversion tabel. mengenai intepretasi skor. The conversion shows that the usability of the system can be included into the "highly feasible" category.

2.4.4 Performance

Assessment of the performance efficiency of the system was done by counting the average of the waiting time from each faculty using the traceview software of the Android Studio. The testing was done by linking the smartphone to the computer unit. The smartphone was of the HTC 10 brand with the specifications Processor Quad-core (2x2.15 GHz Kryo & 2x1.6 GHz Kryo), GPU Adreno 530, Chipset Qualcomm MSM8996 Snapdragon820, Memory 4G RAM, Internal Storage 32GB, monitor screen size 5.2 inches and External Storage 32GB connected to the 4G Telkomsel. Scoring was done by opening all the pages and noting down response-time results. Findings of the performace testing are shown in Table 4 with an overall response time of 3.46 seconds.

3. CONCLUSION

From the presentation and discussion of the results of the study, conclusion can be drawn as follows. The design of the information system of the SAU of the Reasoning Division, based on the Android and Firebase mBaaS using the Relational Unified Process (RUP) method, contains the features of the SAU of the Profile, News, Gallery, and Achievement. Achievement data are accessed through scraping of the presma uny system. The Android-based SAU information system has fulfilled the quality standards of the ISO 25010 criteria on the function suitability aspect (100%) satisfying the quality standard determined by AQuA. On the compatibility aspect, the system reaches 89.99%. On the usability aspect, the system reaches 82.83%, at the "highly feasible" category. On the performance efficiency aspect, the system notes down a response average of 3.46 or "highly satisfying".

Table 4. Results of performance assessment on traceview

No	Task/Page	Response Time (seconds)				
		Test 1	Test 2	Test 3	Test 4	Test 5
1	Splashscreen	6.50	7.20	6.80	7.10	6.00
2	News	2.80	3.10	2.40	2.90	2.40
3	Detailed News	1.70	2.10	2.00	2.60	1.90
4	Gallery	3.00	3.50	4.00	3.20	3.70
5	Detailed Gallery	2.30	2.00	1.80	1.90	1.80
6	Achievement	6.50	6.10	6.70	6.90	7.20
7	Reasoning Achievement	1.50	1.20	1.70	1.50	1.50
8	Sports Achievement	2.10	1.20	1.40	1.60	1.20
9	Arts Achievement	2.40	1.80	1.90	1.50	2.00
10	Special Interest Achievement	2.30	2.20	2.40	2.10	2.20
11	Administrator	1.70	1.80	2.00	2.10	2.20
12	Post News Administrator	5.20	6.00	6.30	7.10	6.80
13	Post Gallery Administrator	5.70	6.20	6.60	5.40	5.80
Average		3.36	3.42	3.54	3.53	3.44
Response Time Average		3.46				

4. ACKNOWLEDGMENTS

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Juan Piece, a Mobile Puzzle Game about Philippine Geography: its Effects on Students' Problem Solving Skills

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ABSTRACT
The study endeavored to develop a 2D infinite runner - puzzle game, called Juan Piece, in order to identify its effects to the respondents' problem-solving skills and to their Philippine geography appreciation as well. The game was deployed to Android smartphones and tablets. The researchers wanted to know if puzzle games like Juan Piece can improve one's problem-solving skills. Paired t-tests and chi-square tests of independence were used to analyze and interpret the data gathered from the respondents. The said tests, all at a 5% level of significance, revealed that 1) there is no significant difference between the problem-solving skills of the respondents before and after playing, 2) game puzzle interest (i.e. whether the respondents play puzzle games or not prior to the study) is independent from respondents' problem-solving skills before and after playing Juan Piece, and 3) there is a significant difference between the respondents' Philippine Geography appreciation before and after playing the game.

CCS Concepts
• **Applied computing→Education→Interactive learning environments • Human-centered computing →Human computer interaction (HCI) →Empirical studies in HCI**

Keywords
Puzzle; video games; problem-solving skills; Android

1. INTRODUCTION
In the past, video games were thought to be a distraction from learning among children. Moreover, these games were associated with various negative conditions such as addiction, violence, and isolation. Though the truth of these views is still debatable, there is no denying that the engagement users have while playing such games is so intense.

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In fact, a growing number of studies point out that games from the simulation and puzzle genres have the most positive impact in learning. Playing these games is often related to improved mental abilities as well.

1.1 Statement of the Problem
The study aims to answer these questions:

1) How are the respondents characterized based on:

a) Mobile operating system (OS) used (i.e.

whether respondents are Android OS users or not),

b) Age,

c) Gender, and

d) Puzzle game interest (i.e. whether respondents are puzzle players or not),

2) Is there a significant difference in the appreciation of respondents toward Philippine Geography before and after playing the game? and

3) Is there a significant difference between the problem-solving skills of gamer and non-gamer respondents before and after playing the game?

1.2 Hypothesis
The researchers hypothesized that there is no significant difference between the problem-solving skills of gamer and non-gamer respondents before and after playing the game.

1.3 Limitations of the Study
The study focused on the development of the mobile puzzle game Juan Piece in order to determine its effects on the problem-solving skills of the respondents. The game is composed of 30 levels, each level revolved around the themes of Philippine landmarks from different provinces, festivals, and trivia. Respondents were students from the UE- Manila campus enrolled in College Algebra offered by the University's College of Arts and Sciences at the time of the study. Qualified respondents played the game for five (5) consecutive days under a self- regulated usage setup and were given pre-tests and post-tests on Philippine Geography appreciation and on their problem-solving skills.

Statistical methods were used such as two-tailed paired t-test and two-tailed chi-square test of independence to examine the data

from respondents. Such data included demographic profile results, pre-, and post-test scores.

2. REVIEW OF RELATED LITERATURE

2.1 Problem-solving as a Cognitive Process

Traditional Gestalt psychology states that human critical thinking capacity is related to learning and awareness [12]. Matlin points out that by utilizing computer, it can exhibit a hypothesis on the grounds that psychology may not demonstrate, that a hypothesis is right, so instead, clinicians can depend on simulations[8]. Computer innovation could be useful as individual associates in critical thinking, and to give a psychological programming and recreating situations, to accomplish a more profound comprehension of the topic and to investigate learning techniques[6] .

Based on intellectual informatics, problem solving is distinguished as a psychological procedure of the mind at the higher subjective layer that scans an answer for a given issue or discovers a way to achieve a given objective. It is perceived that there is a need to look for a proverbial and thorough model of the subjective procedure of human critical thinking to add a strong and intelligible hypothetical establishment for incorporating different hypotheses, models, and practices of problem solving [12].

2.2 Improving Problem-solving Skills of Students

Patterson noticed that an expanded spotlight on educating critical thinking and problem solving has been vital to rebuilding school curriculum reform since such abilities give the premise to all learning[10]. Indeed, the ability to recover and process data and, in turn, propose an answer for a discernable issue represents an art that will extraordinarily propel a student's capability and independence [1].

Problem solving includes utilizing accessible data to distinguish and plan solutions to problems. It is not mystery, but rather an efficient information preparing system in which the student is taught to define and analyze, dissect a problem and to distinguish potential issues and at that point recognize and execute an answer for those issues [9].

Teaching of problem solving requires the creation of an active learning environment, where students need to take obligations in a group for gathering, exchanging and embracing new ideas. Rather than being a passive receiver, students take part in the pedagogical procedure to be able to learn the knowledge. Critical thinking likewise has basic impact in making regulative and transformative abilities. The transformative aptitudes are: watching the issue, addressing, conjecturing, arranging, examining, exploring, breaking down and translating information and lastly imparting results. The regulative capacities are: organizing, watching and assessing one's studying [5]. Heller et al., settled that problem solving requires utilization of an earlier learned hypothesis by the solver. This requires investigative point of confinement and a capacity to separate an issue and to unravel it. Successful critical thinking ordinarily includes working through various strides or stages. Follow the steps and you will get the right solution to address the issue [7].

2.3 Puzzles

Puzzles are dilemmas for which there is regularly one and only arrangement that can be decoded by applying standards or frameworks to the issue [13]. According to Kim, Jeon & Park , a puzzle game is a game genre with simple rules and a property of strong addictiveness. Puzzles should have these qualities in order for the players to have an idea about the game even without any experience with it [11]. The difficulty increases when you have an infinite mode of stream because that is the quality that puzzle must possess. Nowadays, it is a culture and an important part of our lives and we often get amazed on how we are exceeded by our limitations and playing these games became a leisured thing for us. Awareness, memory, logic and application of skills can be the potential learning areas while playing this game. Puzzles are known to output a lot of benefits in terms of analysis, strategy and tactics skills.

2.4 Impact of Mobile Games to Students

At present, digital games are now evolving in a rapid rate. Since almost everyone has a smartphone, several researchers are taking advantage to merge education and mobile games together. Hence, mobile game based learning is born, also known as educational mobile games. The utilization of instructive recreations on smartphones remains generally new. However, a study about educational mobile games now exists.

Allsop analyzed rudimentary children's view of learning with math games utilizing iPod touches as a part of an elementary school in London [3]. He used classroom perceptions, pupil's work, bunch interviews and through survey. Some of the students expressed that the innovation helped them learn better and made adapting all the more intriguing. should not only be the basis for a teacher to evaluate student's performance. But, how does mobile learning accomplish such an effect? Mobile learning permits students to learn anyplace and at whatever time which urges students to learn in both their home and school situations. Today, students can get information on their gadgets. At the point when there is a class of students with various needs that require diverse learning styles, this can be an extremely valuable device for teachers.

In a thorough study, Attewell proposed that versatile learning may have a positive commitment in different regions. Her study discoveries showed that versatile learning helped learners to enhance both their proficiency and numeracy aptitudes. She additionally reported that portable learning helped learners to concentrate on learning for more and helped them to raise their self-regard and self-assurance [4].

In his paper, Al-Fahad investigated the state of mind and impression of 186 university students from various colleges towards adequacy of mobile learning in their studies [2]. The greater part of the students upheld the idea that the remote systems expand the adaptability of access to assets in learning and that they could work freely of variable assets like labs or library PCs. The students additionally were quick to utilize all sources of m-learning approaches through laptops, mobile phones with the goal that entrance to data would be whenever and wherever. As the date uncovers m-learning exercises can much better connect with students in the learning procedure. Students in this study changed from detached learners to genuinely drew in learners who are behaviorally, mentally and sincerely included in their learning undertakings. The Mobile advancements are seen as a compelling instrument in enhancing correspondence and learning.

3. DATA AND METHODOLOGY

3.1 Data

The researchers used the non-probability sampling technique called purposive sampling. Selection was done after analysis of

submitted demographic profile questionnaires. After the post-test, the respondents were grouped as gamers or not. In order to have equal group sizes, a simple random sampling was done.

3.2 Methodology

The problem-solving skills of the respondents were compared before and after they played Juan Piece. A set of pre-test and post-test for Philippine Geography appreciation was given to each respondent to see if there is a difference on how they perceive Philippine Geography before and after using game. Another pre-test and post-test set was given which comes in the form of general math problems. The set was used to compare if the respondents' problem-solving skills changed or not.

After qualifying as respondents, the subjects will play the game for five (5) consecutive days on their own Android devices. The respondents will play the game at least once a day in a self-regulated manner. After five (5) consecutive days of using the game, the software usage logs will be collected and will be statistically treated for evaluation.

The study used percentages, means, and frequencies. A paired sample t-test was conducted in order to assess the overall difference in respondent scores before and after playing the game. Another paired sample t-test was used to determine if there was a difference in the respondents' Philippine geography appreciation. Furthermore, a chi-square test of independence was used to determine if there is a relationship between the respondent's puzzle game interests and their pre-test and post-test scores. To determine the significance of the results, all tests used a 5% level of confidence.

4. RESULTS, ANALYSIS AND EVALUATION

Table1. Pre-test and Post-test means for problem-solving skills of gamer, non-gamer and overall groups

	Pre-Test	Post-Test
Gamer	5.5417	5.2083
Non-Gamer	5.0000	5.8333
Overall	5.2709	5.5208

In order to determine if there was a significant difference between the overall pre-test and post-test means, a paired t-test was used. The researchers hypothesized that there is no significant difference in the overall pre-test and post-test means of the respondents. Using a mean sample variance of 10.1489, 47 (n-1, where n =48) degrees of freedom and a confidence interval of 0.05, the hypothesis was accepted. Therefore, no significant difference in the overall pre-test and post-test results of the respondents was found.

Table 2. Pre-test results for Philippine Geography of gamer and non-gamer groups

	Below Average	**Average**	**Above Average**	**Total**
Gamer	10	1	13	24
Non-Gamer	13	2	9	24
Overall	23	3	22	48

To determine if there is a relationship between the respondents' puzzle game interest and their pre-test scores, a chi-square test of independence was used. The researchers hypothesized that there is no relationship between the respondents' puzzle game interest and pre-test scores. Using a 2 ((rows-1) * (columns-1)) degrees of freedom and a confidence interval of 0.05, the hypothesis was accepted. Therefore, no relationship between the respondents' puzzle game interest and pre-test scores was found.

The same statistical treatment was used for the respondents' post-test scores. The researchers hypothesized that there is no relationship between the respondents' puzzle game interest and post-test scores.

Table 3. Post-test results for Philippine Geography of gamer and non-gamer groups

	Below Average	**Average**	**Above Average**	**Total**
Gamer	13	4	7	24
Non-Gamer	12	4	8	24
Overall	25	8	15	48

Using a 2 degrees of freedom and a confidence interval of 0.05, the hypothesis was accepted. Therefore, no relationship between the respondents' puzzle game interest and post-test scores was found.

Table 4. Overall means for Philippine Geography appreciation of respondents

	Pre-Juan Piece	**Post-Juan Piece**
Overall	4.0319	4.3653

Lastly, a paired t-test was employed to determine if a significant difference in the respondents' Philippine geography appreciation before and after playing the game exists. The researchers hypothesized that there is no significant difference in the respondents' Philippine geography appreciation before and after playing the game.

Using a mean sample variance of 0.038, 47 (n-1, where n =48) degrees of freedom and a confidence interval of 0.05, the hypothesis was rejected.

Therefore, a significant difference in the overall in the respondents' Philippine geography appreciation before and after playing the game was found.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the results computed, the researchers were able to conclude that 1) there is no significant difference between the problem-solving skills of the respondents before and after playing the game; 2) game puzzle interest is independent from the respondents' problem-solving skills before and after playing the game; and 3) there is a significant difference between the respondents' Philippine Geography appreciation before and after playing the game.

5.2 Recommendations

With the said conclusions, the researchers highly recommend the following to future researchers: 1) conduct the study in a larger and more diverse sample to determine if a different result will exist; 2) use a controlled-usage setup for the game; 3) conduct the study at the start of the semester if respondents are students; 4) development of the game for another mobile platform; and 5) incorporate another subject area in the study.

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The Impact of Educational Microcontent on the Student Learning Experience

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ABSTRACT
This case study investigates educational microcontent as an online delivery mechanism for course content, specifically assessing its impact on the subjective student learning experience. Microcontent was introduced as a supplementary resource to students across three Computer Science courses at the University of New South Wales (UNSW). Content was distributed via Snack, a platform developed by the research team for efficient creation and distribution of short, "bite-sized" instructional videos. The case study suggests microcontent had significant positive impact on students' non-achievement outcomes; improving confidence, interest in subject material, academic self-efficacy and learning ability, as well as self-perception of achievement outcomes such as learning ability and academic performance. Findings support the position that microcontent is an effective supplementary tool for teachers which can engage a large student audience and positively impact their learning experience.

CCS Concepts
• **Applied computing→Education→E-learning**

Keywords
E-learning, digital education, microcontent, videos, Snack

1. INTRODUCTION
This case study aims to deepen our understanding of the student experience of video as an online learning resource.

Short, online videos known as "microcontent" pervade digital education, being widely available on video hosting applications such as YouTube, massive open online courses (MOOCs) such as Coursera and EdX, and open source lesson providers such as Khan Academy. While extremely popular amongst students, the body of research surrounding microcontent's instructional effectiveness is mixed: despite the fact that video is highly accessible and enables self-paced learning, evidence suggests the risk of a passive, impersonal experience that can impede on long-term engagement and retention of knowledge [1]. With such popularity, the medium's impact on student learning remains to be more deeply understood.

To assess microcontent's impact, a case study was conducted at UNSW across three Computer Science courses. Sets of videos were introduced in a variety of contexts as a supplementary resource for students, created and distributed via Snack, an online platform developed by the research team. Student interactions with the microcontent were observed via Google Analytics (GA), and a post-intervention questionnaire probed student outcomes and perceptions of microcontent's impact on both achievement such as academic performance and non-achievement outcomes such as student confidence, academic self-efficacy and interest in course material.

The case study gives insight into microcontent's impact on the student learning experience, to better understand what role – if any – microcontent should play in modern pedagogy.

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2. MICROCONTENT DESIGN
The design of the Snack platform is informed by best practices regarding microcontent. Specifically, Snack's videos are interactive whiteboard animations with background narration, engaging both visual and auditory channels to reduce working memory load and increase retention [2]. Snack limits maximum video duration to 10 minutes, catering to limited attention spans of students online [3]. The videos are also interactive, encouraging student participation by allowing spatial control of the video canvas [4].

Figure 1. Snack's video creator (left) and player (right)

2.1 Modularity
2.1.1 Duration
Deteriorating student attention spans are consistently evident in studies of educational video. For example, on EdX, once a video's duration exceeded 12 minutes its average playback dropped to just 3 minutes per session [3]. Additionally, in 6.9 million EdX playback sessions Guo and colleagues revealed that median playback duration for a video of any length was only 6 minutes [1]. Subsequently, Snack enforces creation of digestible, modular chunks of content through a 10 minutes limit on a video's duration.

2.1.2 Repetition

In the context of educational video, delivery of short bursts of content followed by spaced intervals and repetition has been shown to be a highly effective way to retain new information. This retention can be attributed to Eibbinghaus' theory of spaced learning, which describes a human tendency to rapidly forget knowledge after it is learnt [5]. Ebbhinghaus argued that this forgetfulness can be minimised in a compounded way by revisiting content in regular, spaced intervals.

The benefits of online microcontent therefore lie in accessibility and control, which both enable spaced learning. By giving students the ability to review microcontent on-demand and providing granular control over pace and playback, learning can be reinforced at individual levels. Snack provides the basic functionality for individual navigation in a video player, such as the ability to seek, pause, rewind and replay, but emphasises more granular controls such as playback speed, panning and zooming to give the student user end-to-end control over their learning experience.

2.1.3 Structure

Modular content requires coherent structure and ordering. Mayer and Moreno suggest that mentally organising materials into an order or "playlist" which emphasises the use of existing knowledge is crucial in video design [2]. Additionally, thoughtfully structured microcontent has been shown to decrease learning difficulty and anxiety and improve academic self-efficacy [6]. Snack therefore allows creators to seamlessly organise videos into an ordered playlist for students.

2.2 Modality

Building on Ebbinghaus' spaced learning principle is Mayer and Moreno's Cognitive Theory of Multimedia Learning, which provides a more complete description of cognitive load in the context of educational video [2]. Here, auditory and visual inputs are loaded into working memory with limited capacity, and this information is gradually processed and encoded into long-term memory which has virtually unlimited capacity. The theory posits that while each channel has limited capacity, when both are engaged simultaneously a learner's total working memory load is maximized.

Subsequently, an appropriate format of microcontent is the whiteboard video, which uses whiteboard animations with background narration. This engages visual and auditory channels in a highly complementary way, as the simplicity of the whiteboard making up the visual component removes visual noise and makes it easier for the student to follow the teacher's train of thought [2]. This is more than conjecture: Wiseman's case study showed 15% greater retention of content when whiteboard animation was added to a "talking head" video in a sample of 2000 students [7]. Furthermore, Guo and colleagues showed that whiteboard videos from Khan Academy garnered greater student playback than traditional slide/code tutorials [1]. Snack uses this popular whiteboard video format with interactive enhancements.

2.3 Interactivity

Interactive features in microcontent have a shared goal of decreasing the passivity of video. Interactivity can vary from simple features such as temporal seeking to more involved features such as embedded quizzes. Lawson et al[4] inserted eight guiding questions into their videos for one section of a social psychology class, using unaltered video for other sections as a control. They found students who answered the guiding questions throughout videos outperformed students using the unaltered video streams. In a similar study, Zhang et al [8] found students who used videos with interactive features had a more positive attitude towards the learning experience. Here, evidence suggests that viewing methods which encourage active participation and emulate a classroom environment are more effective. Snack implements interactivity by allowing users to control spatial movement (panning, zooming) on an infinite canvas and copy and paste text directly from videos.

3. CASE STUDY

3.1 Population

During the intervention semester, Snack was integrated into three Computer Science courses at UNSW. A large quantity of microcontent was produced by student tutors and consistent, course-wide engagement was observed. Details of the student populations and intervention are summarised in Table 1.

Table 1. Summary of course populations

Course	Number of students enrolled	Number of videos released	Total duration
A	707	21	1h 45m
B	564	9	1h 20m
C	356	30	2h 50m

In each population, most students were completing a degree in the School of Computer Science at UNSW. Each course was a core Computer Science unit, meaning cohorts were large and had some overlap. In each case, videos were offered as an optional supplementary learning resource.

3.2 Intervention

Microcontent was scripted and recorded by UNSW student tutors, including members of Snack's development team. In Course A, videos were tailored towards the students' weekly lab exercises and reviewed the exercise structure, common mistakes and relevant theory needed to get started. Videos were shared with students via webcms3 (Course A's LMS) and a direct link to all videos (organised into playlists) on the webcms3 main page. To increase exposure, videos were also embedded into HTML pages which contained instructions for each lab exercise. An example of this is embedding shown in Figure 2.

Figure 2. Course A pre-lab video embedded on LMS

In Courses B and C, microcontent was conceptual and acted as an alternative medium for students to learn course theory. Distribution was more limited in these courses, with videos being shared via forum posts, emails and social media.

3.3 Questionnaire

Our questions were designed to assess how non-achievement outcomes such as confidence, self-concept and interest in course content were affected by microcontent. Additionally, questions on achievement outcomes were included to assess self-perception of microcontent's impact on learning ability and academic performance.

The questionnaire was distributed to 1627 students across courses A, B and C. Distributing to three courses, each with its own use case for microcontent, allows for proof of translation and reproducibility: if responses are consistently positive or negative across many courses, a stronger argument can be made for microcontent's impact on the student learning experience.

4. RESULTS

4.1 Engagement

Herein, engagement is measured with two key metrics: the quantity of students reached and the quality of individual student interaction.

4.1.1 Reach

Week-by-week engagement for each course over the intervention semester is summarised in Figure 3 (source: Google Analytics).

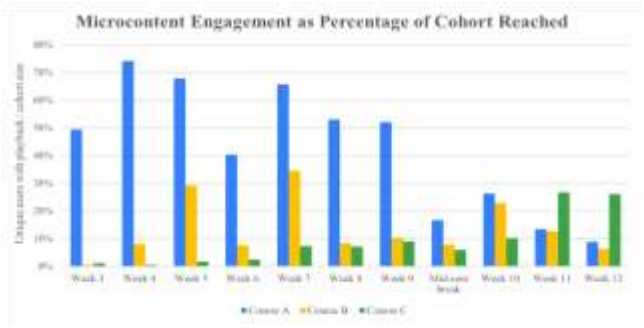

Figure 3. Microcontent reach for Courses A, B, C

As we can see, engagement fluctuated throughout the semester, with primary drivers being relevance of microcontent to assessable items and distribution methods. Accounting for weeks 3-12 where pre-lab videos were released, an average of 54% ± 11% (α=0.05) of Course A's students engaged with videos on a weekly basis. The reach of microcontent in Courses B and C were significantly lower: Course B reached 8.9% ± 5.5% (α=0.05) of the cohort, while Course C reached 8.6% ± 2.3% (α=0.05) of the cohort. In these courses, reach was hamstrung by limited distribution. Unlike Course A where videos were directly embedded into the course's LMS, Course B and C's videos were only shared via informal forum posts and comments.

4.1.2 Interactions

Interaction quality looks at how long students watched videos for, when they dropped off and how regularly they returned to watch more. Given the questionnaire is built around students' individual experience with microcontent, higher quality interactions better inform student respondents. Figure 4 shows weekly interactions for each course, represented as the average duration of playback per user. This metric accounts for longevity of student engagement and total available microcontent. Here, only the subset of students who engaged with microcontent is considered.

As we can see, playback duration was more consistent between courses. Course A had steady engagement across lab weeks 3-10, with average playback of 9.3 ± 1.2 (α=0.05) minutes per user. An average of 17.2 minutes of lab-related microcontent was released each week, meaning engaged students watched 54% ± 7% (α =0.05) of microcontent each week. Coupled with 54% cohort reach, we can conclude strong engagement with Course A's microcontent.

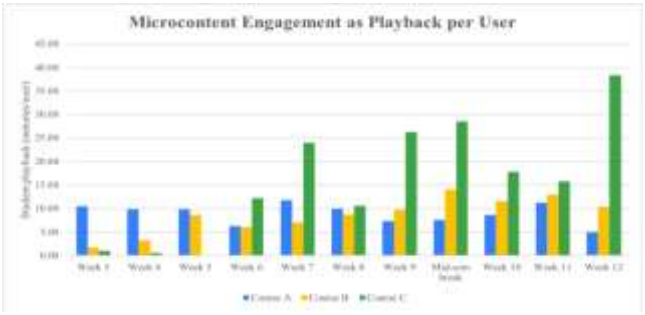

Figure 4. Microcontent interactions for Courses A, B, C

Additionally, while videos reached a smaller percentage of Course C students, individual interactions were much stronger, with a higher average playback of 23.0 ± 5.5 (α=0.05) minutes per user per week when content was available in weeks 6-12. Course B also had interactions that were equally as strong as Course A's interactions, with 8.6 ± 2.3 (α=0.05) minutes per student per week. Despite microcontent being an optional resource, engagement quality in each course was significant and warrants further analysis of impact on student learning.

4.2 Questionnaire

Questionnaire responses were collected from 177 students. 69% of respondents were enrolled in Course A, followed by 29% in Course B and 23% in Course C. Notably, 21% of respondents were enrolled in two or more of Courses A, B or C simultaneously. Gender breakdown of respondents was 24% female and 74% male, which aligns with the CSE faculty's official student breakdown of 25% female and 75% male students[1] and suggests the population is fairly represented by questionnaire respondents in gender terms.

4.2.1 Six-Point Likert Responses

The first section of the questionnaire asked a set of six-point Likert scale questions to quantitatively measure student sentiment towards Snack's videos. Figure 5 summarises responses, where a score of 6 represents "strong agreement" and a score of 1 represents "strong disagreement".

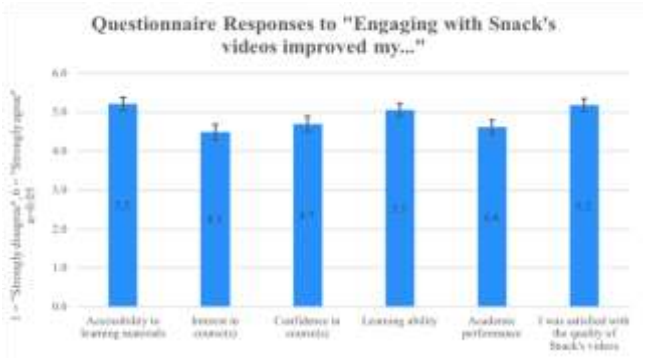

Figure 5. Six-Point Likert scale questionnaire responses

[1] Sourced from UNSW CSE faculty's enrolment data.

For each question, responses skewed towards "agree" and "slightly agree" categories. 90% of students "slightly" to "strongly" agreed that Snack videos made course learning more accessible, while 94% of students "slightly" to "strongly" agreed that Snack's videos were satisfactory as a supplementary resource, conforming to the popularity of microcontent amongst students.

For non-achievement outcomes, students "slightly agreed" (α =0.05) that they felt more confident and more interested in course content as a direct result of Snack's videos. Moreover, students "slightly agreed" to "agreed" that microcontent improved their learning ability and "slightly agreed" that microcontent improved their academic performance (α =0.05). This suggests a self-perception of improved retention and application of material.

When segmenting responses by student engagement, those who engaged with Snack's videos more than once per week reported greater confidence, learning ability and academic performance. Between regular and irregular engagement populations, effect sizes (measured with Cohen's d value) ranged from 0.38 for difference in learning ability to 0.51 for difference in academic performance, indicating engagement had a "small" to "medium" effect size on these outcomes [9]. This suggests a causal link between regular engagement with Snack's videos and self-perceived improvements in learning.

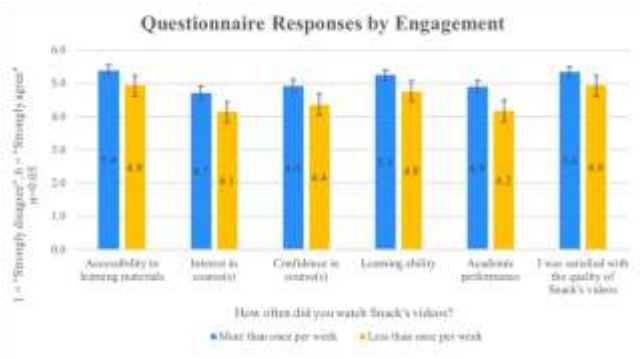

Figure 6. Questionnaire responses by engagement

Segmenting responses by gender and course drew trivial effect sizes (< 0.2) and no statistically significant difference ($p < 0.05$) for each question, suggesting this positive student perception of microcontent is reproducible across genders and cohorts.

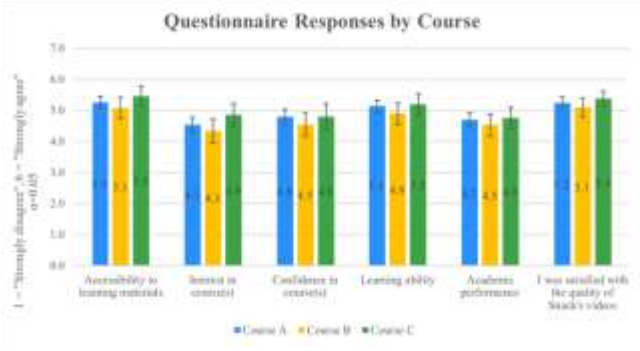

Figure 7. Questionnaire responses segmented by course

4.2.2 Open-Ended Responses

The second section of the questionnaire asked two optional, open-ended questions. Students were asked to describe the best parts of Snack's videos and to suggest improvements.

Of the 117 responses to the "best parts of Snack" question, 38 students praised the clarity of explanations in the microcontent, attributing clarity to the use of whiteboard animation and real-time code editors coupled with narration. Students stated "the dynamic nature of [videos]... with live code... was extremely helpful" and the "combination of visual imagery and live code… with narration and explanation was clear and easy to understand". This aligns with responses from a separate multiple choice question, where 83% of students claimed they used Snack's videos to "clarify points they didn't fully understand in class". It also supports literature suggesting microcontent which engages both visual and auditory modalities maximises a student's ability to digest content [2]. Moreover, 18 students enjoyed the interactive components of the Snack's videos, citing the ability to "move around the page", "zoom in on annotations", "focus on areas" and "paste code examples in real-time".

Second to clarity was relevance. 25 students liked the way microcontent was tailored towards their course, stating videos were "specifically related to course content, unlike YouTube videos". For Course A, videos were designed around lab exercises, with students stating they provided a "solid foundation for the lab… I felt less stressed as a result" and "helped [them] understand how to approach the lab". One student also found content more relatable because it was "taught by students… so it was much clearer".

Modularity of microcontent was also praised. 19 students thought videos were "concise and clear", "straight to the point", "time-cost effective" and "short and succinct explanations of big topics". Some students also claimed the videos "covered a 2 hour lecture in 10 minutes" and that they "had an easier time focusing… because the videos were much shorter in length compared to lectures". These findings support literature suggesting students prefer to consume microcontent in short, modular chunks, however they challenge some reviewed literature which suggest student focus wanes more readily when watching microcontent online than lectures face-to-face [3].

Lastly, 11 students said the accessibility of video was its best feature, stating they could "work at [their] own pace", "revisit [videos] whenever I want… it's like having an on-the-go tutorial" and that videos were "really useful and convenient for when I need to catch up". Students also enjoyed the granular control of video, citing the ability to "replay parts I didn't understand" and "rewind [videos] if necessary". At a higher level, one student claimed video "diversified methods available to [them] to learn". While most students cited interactivity, relevance and conciseness as their favourite features of the microcontent, when asked how they use Snack's videos in a separate multiple choice question (with the ability to select 1 or more option), 49% said they used videos as a "revision tool for assessments", 45% said they used videos to "catch up on missed classes" and 48% said they used videos to enable self-paced study. Accessibility and control are a crucial utility underpinning microcontent's value as a learning resource.

The second open-ended question asked how Snack's videos could be improved. The majority of responses addressed bugs and usability issues on the platform, such as problems with audio quality, latency and mobile responsiveness. These issues stemmed from Snack's lean development process, which prioritised iteration of features over robustness in the intervention semester. Majority of issues were reported by students as they emerged via a bug tracking feature and were quickly resolved. Latency was a product of high, concurrent engagement, causing servers to

overload during peak traffic times (such as during a lab session). Notably, Snack had no downtime over the entire intervention semester, and many students added that these issues did not impede on their learning experience.

The second most common request was for more content, with students asking for "more videos", "more topics", "more examples" and "more revision content… covering a broader area of materials". The frequent request for "more" reveals a growing student preference for microcontent as a learning resource.

Overall the questionnaire suggests student learning was positively affected by microcontent in non-achievement outcomes such as confidence and academic self-efficacy, but also in a self-perceived learning ability and academic performance.

5. DISCUSSION

The methodological position taken in this research is that all educational experiments are biased and therefore not definitive, but can provide useful insight. When analysing a questionnaire built on experiential and opinionated data, it is difficult to draw far-reaching conclusions about microcontent's impact. Natural biases emerge in respondents. In this case, students could have been more inclined to leave positive responses due to the relatability of students authoring the microcontent, dissatisfaction with course authorities and course structure, or limitations of existing course materials.

One such bias relates to student performance. In the questionnaire, 91% of students claimed improved learning ability and 81% claimed improved academic performance as a direct result of Snack's videos. While these findings further indicate improved confidence and academic self-efficacy, they do not provide strong grounds for claims of improved performance in terms of a student's ability to retain and apply knowledge learnt from microcontent. Objective questions such as this are typically polluted by a discrepancy between belief and behaviour in respondents [10]. Here, self-perception does not match reality: analysis of past and present Course A cohorts shows no statistically significant improvement in grades and no correlation with video engagement, despite 81% of students claiming improved performance as a direct result of Snack's videos. It is impossible to know which data is limiting: the questionnaire or lab marks. In either case, findings do not provide grounds for conclusions about microcontent's impact on a student's academic performance - they only suggest a self-perception of improved learning ability.

Creation of microcontent also had limitations. The team of students developing Snack created 92% of microcontent that was distributed to Courses A, B and C. Due to inexperience, there are risks that Snack's microcontent is too leading, revealing too many hints about labs to make it easier for students to complete, influencing sentiment towards microcontent. To control this bias, a constraint was imposed by course authorities whereby videos could only rephrase text included in lab exercise instructions or lecture notes and could not contain additional information that hinted at solutions or simplified exercises. To avoid this bias in future work, microcontent could be created by teaching staff external to research and development team. Additionally, microcontent had minimal quality assurance. While videos were reviewed by head lecturers and saw many iterations, quality was not effectively measured on the student side. Quality could help better describe the nuances of engagement data, and mechanisms for measuring quality could be used in future work.

Despite minor limitations, findings on non-achievement outcomes were overwhelmingly positive. Majority of students believed their confidence, self-efficacy, interest in the course and overall learning ability was improved as a direct result of Snack's videos. These findings were translated and reproduced across three Computer Science courses, with positive experiences emerging from each course despite varying use cases and video styles (for pre-lab, conceptual and theoretical videos). While the 177 respondents made up a small portion of the overall population of 1627 students, they were shown to fairly represent the population through cross-validation of engagement data from GA and gender data from the CSE school's enrolment records. We can conclude that in the context of the subjective student learning experience, microcontent had a positive impact.

Additionally, given Snack's videos were an optional resource in each course, engagement was disproportionately high. Over the 12 week intervention semester, Snack had 7300 unique users access the site, with 36800 sessions and a low bounce rate of 6%. Almost all of these sessions converted to video playback with an average session duration of 6 minutes. With a plethora of options for online learning, students chose Snack's videos because of their relevance and adherence to best design practices.

Questionnaire responses reinforced the effectiveness of best design practices, with students praising Snack's "bite-sized" modularity and structure, its interactive interface and its multi-modal format of whiteboard animation and narration.

6. CONCLUSION

Our findings suggest microcontent has the capacity to significantly support the subjective student learning experience. Across three Computer Science courses, microcontent positively impacted student confidence, course interest and self-concept, and fostered a self-perception of improved learning ability and academic performance. High engagement and positive feedback further suggest Snack's video format has a strong pull on students, making it a potentially powerful communication tool for teachers.

This study supports microcontent's use as a supplementary resource in Computer Science education and potentially beyond, acting as an online medium to complement offline, lecture-based delivery and enable self-paced learning for students.

7. ACKNOWLEDGMENTS

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Piloting Experiential Learning through 360º Video and 3d Printing to Improve System Modelling

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ABSTRACT
This research investigates the impact of experiential learning methods in teaching system modelling in a higher education ICT classroom. We hypothesize that the integration of visualization and gamification by incorporating 3d printed objects and a virtual video 360^0 case scenario can improve learning motivation, engagement and enhance learning outcomes. The data was gathered through a usability test using a Likert scale from students (n=24) of two conditions (control group n=12 and experimental group n=12), using a design-based research methodology. Significant results were found for 11 of the 14 usability questions asked of the participants during the study. Preliminary results show that the experiential learning activities promoted engagement and motivation and had a positive effect on learning. Using 3d printed objects provides an added layer of facilitated interaction for individuals and between learners on the usability measures of manipulability, memorability, navigability and communication. However, measures of creativity, visibility and efficiency were not significant due to the delivery and novelty of the approach. Based on the positive results of the usability test, further work is required to refine the intervention. This includes unpacking the effects of visualization and gamification on motivation, engagement and learning in system modelling.

CCS Concepts
•Computer Systems Organization • Information Systems • Computing Methodologies

Keywords
Experiential learning, system modelling, ICT education, design-based research, 3d printing, 360 video

1. INTRODUCTION
The use of unified modelling language (UML) allows designers to describe various components of the system. However, it does not describe a process for capturing requirements [10]. When using UML, learners are challenged to conceptualize a problem domain or narrative for better modelling decisions [28]. Some of the difficulties of understanding the system itself can lead to disconnection and therefore learning disengagement [11].

The value of traditional learning approaches in system modeling has been challenged with regards to students' understanding, learning performance and mastering of modelling techniques [28]. The use of multimodal learning environments can be used in ICT system analysis & design to enhance critical thinking, improve problem-solving activities, support system thinking and promote learning [2].

Important progress has been observed in the use of multimodal visual representations such as 3d printed objects and 360 video as they can be used in education and training [1]. These characteristics in conjunction with other methods such as incorporating game-based learning in the classroom, can offer enhanced feedback to facilitate understanding compared to the traditional didactic or written approaches [5]. The use of interactive visualization through multi-dimensional graphics and simulation could provide an opportunity to present key learning content for students using multiple representations [6; 18]. Multiple representations support a variety of learning activities and can provide unique benefits when students are learning new concepts or complex ideas [1].

3d printing has been utilised to support learning in a range of educational and training contexts. The human sense of touch is a dynamic, informative, and convenient perceptual system to connect and construct meaningful understanding [17]. The efforts to use image-based 3d printing tools to create models and molds have been used for medical learning environments, additive manufacturing design and manufacturing processes [3]. The use of 3d printing haptic tools has the potential to produce informative representations and can be used for science, technology, engineering, and STEM topics [19]. Interactive and hands-on learning activities are considered as promising strategies for providing instructional content that allows the learner to engage actively in the learning process [15]. Another emerging approach, gamification, is described as the incorporation of game technology and game design methods with the purpose of solving problems and engaging users [8]. Gamification is the incorporation of game elements and game mechanics into a non-game context [16]. The role of gamification is to evoke psychological experiences that match a game environment by applying the mechanics of gamification in educational settings [12, 14]. Gamification's main goal is to raise the motivation of users by incorporating game-like techniques such as scoreboards,

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situational scenarios and adapted feedback [10,26]. In addition, McGonical refers to the ongoing feedback provided to participants in games such as Tetris [22]. There is visual (pieces), quantitative (score), and qualitative (levels) feedback provided during the game; yet traditionally it is challenging for educators to recognize the importance of feedback, and how and when to provide it on student work [22].

Taking 3d printing into the area of instructional design programs will also benefit students [21]. According to Howard and Vance (2007) [16], a combination of haptics and physically based modelling significantly improved learning motivation and provided a more realistic virtual assembly experience. In addition, visualization and gamification facilitate methods of interacting with information [5,7] and have positive effects and benefits in the classroom [18]. Many students face difficulties in conceptualizing modelling process, which leads to difficulties scaffolding and understanding theoretical models particularly around the complexities of system design thinking [24]. As a result, educators are challenged to find new avenues of transforming abstract system thinking into more concrete design thinking that opens more opportunities for clearer conceptualization of systems, interaction and design experiences [2, 26].

Understanding the problem of system abstractions can improve students' understanding of modelling. Visualization combined with game elements shows potential to assist students with system modelling. We hypothesize that the integration of visualization and gamification, by incorporating 3d printed objects, can improve learning motivation, engagement and enhance learning outcomes. The developing modelling skills in system analysis and design accounts for conceptualizing and translating ideas into models. This study contributes to the current body of literature on learning the challenges, skills needed and immersion using experiential multimodal methods and how they can scaffold learning in new ways, so learners are motivated in the learning experience. An essential question that arises from this study is how visualization using 3d printed components and 360^0 video can be used as a method to assist students with their comprehension of systems and simplify problem complexity by using visual representations of the system and its abstractions. In the usability testing, we investigated the relationship among these variables, and the extent to which they enhance learning. The proposed method is designed to enhance students' knowledge and skills in system modelling as well as to provide informative representations for cognition.

2. RESEARCH METHODOLOGY

The aim of this research is to investigate the learning performance and engagement of students using visualization and 3d printed objects in a game-like context when learning ICT system modelling. This section presents a research methodology that describes the actions taken to define problems encountered when modelling ICT systems through UML and provides a theoretical foundation to answer the research questions. This work will adopt the 4C method (see Figure1) for testing as proposed in [24]. This framework proposes a sequence of activities developed to facilitate understanding of the requirements, solutions and incremental modelling development. This method will guide students with solution support to build a model by using four steps (Conceptualization, Connection, Construction and Consolidation). This 4C method loops through specific steps and a series of iterative implementation of experiments to test learners' modelling improvements. In this research, the 4C framework informs an underlying design-based research (DBR) methodology, as proposed by [25].

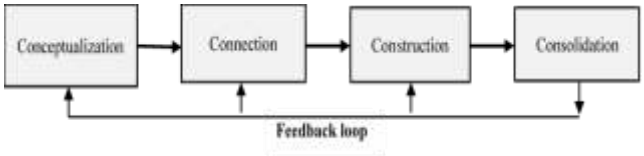

Figure. 1. The '4C' framework

Due to the flexibility and adaptability of DBR, it has been used across a range of educational environments including conducting research in the classroom [27] and designing instructional learning environments in information systems [15]. DBR offers a cyclical loop that simultaneously addresses and reflects on the analysis of the problems and its practicality [2] (see Figure 2).

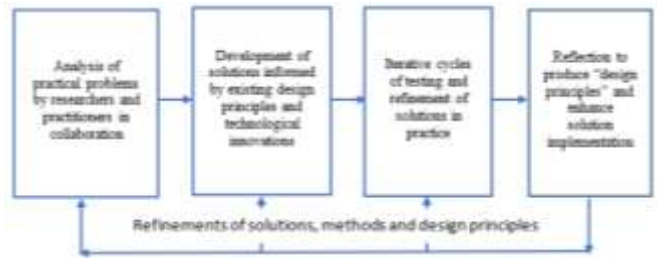

Figure 2. Design Based Research Cycle (2008, p.34) [2]

There are currently three proposed loops for the experimental implementations of the larger study and each loop involves the use of the DBR in an ongoing manner. However, for this study only the implementation for Loop 1 will be examined as a base for tool evaluation and effectiveness of the modelling solution.

The implementation of Loop 1 included the use of visualization where students interacted, discovered and immersed in the visual case scenario. This incorporated a set of 3d models that represented users, activities and connections. This activity assisted students in a gamified learning context and can be used to reinforce engagement based on students' actions. Participants in the study were recruited as volunteers from an Australian university enrolled in a systems analysis unit from an ICT program. Ethics clearance was granted for this study before running the experiment.

A sampling of (n = 24) ICT first-year student participants were randomly assigned to one of the two conditions (experimental and control). Twelve participants were assigned to the control group condition (CG), while twelve were assigned to the experimental group condition (EG). All participants (students) received a short lecture PowerPoint slide highlighting the 4C framework that provided an overview of the process of constructing their model (see Figure 3). Students had a base line competency in using UML before starting the experiment.

Figure 3. 4C framework steps

Students were then divided into two groups and participated in the intervention which was followed by a usability ranked on a Likert scale of 0-5 test outlined in Table 1 – and validated in [4].

Table 1. Usability assessment survey

[Likert Scale 0 no relevant – 5 very relevant]						
1. Accessibility: Visualization is readily accessible	0	1	2	3	4	5
2. Learnability: Visualization is easy to learn	0	1	2	3	4	5
3. Efficiency: Visualization is efficient to use	0	1	2	3	4	5
4. Satisfaction: Visualization provides satisfaction (confidence) of the design	0	1	2	3	4	5
5. Memorability: Visualization is "sticky" and memorable to support the design	0	1	2	3	4	5
6. Error Free: Visualization is free from visual and design errors	0	1	2	3	4	5
7. Manipulability: Visualization can be manipulated - e.g. rotation, time, amplify	0	1	2	3	4	5
8. Navigability: Visualization allows the user to change their viewpoint	0	1	2	3	4	5
9. Visibility: Visualization provides clear detail to interpret the design	0	1	2	3	4	5
10. Real world: Visualization provides a match to the real world	0	1	2	3	4	5
11. Communication: Visualization aids stakeholder design communication	0	1	2	3	4	5
12. Creativity: Visualization allows the user to be creative with the design	0	1	2	3	4	5
13. Engaging: Visualization is meaningful	0	1	2	3	4	5
14: Motivating: Visualization provides acceptance of the design	0	1	2	3	4	5
Additional Comments						

The traditional method control group received a narrative of the case study describing the library booking system and where students had to read the narrative before they identify all the actors using the library system. They then defined the requirements and meaningful connections by drawing the use case model onto a piece of paper (see Figure 4).

Figure 4. Written narrative and use case representation

The experimental group watched a 360^0 video presenting a virtual case study representing a library booking system where students were able to explore, extract and classify information (see Figure 5) to represent a use case model using 3d components (see Figure 6).

Figure 5. Virtual case study

Figure 6. Use case model representation

Following this, in groups of three, students identified the number of actors and entities involved using 3d physical representation of UML symbols to help them to connect their findings. The experiment focused on syntax learning and system modeling analysis, comprehension of system modelling. For this purpose, the use of 3d tools posed as syntax symbol representations (see Figure 2). Once students selected and classified the relevant actors and activities, they presented and progressively described their findings in class. The inclusion of an interactive video to present the case study supported by 3d printed tools are both visual aids to assist students through the different phases of the 4C framework. The video allows students to conceptualize in the first phase by reducing cognitive processing through immersion compared to traditional reading. Whereas the 3d printed tools allow the recognition of the syntax to be used to classify actors and make

connections (second phase), construct activities (third phase) and consolidate the previous steps (fourth phase).

3. RESULTS

The administered usability survey is presented in Table 1, in which each measure was ranked on a Likert scale from 0 to 5 with 0 representing not relevant and 5 representing very relevant. Results of the usability test were analyzed using SPSS v25. Table 2 presents the paired statistics of the usability test. Table 3 presents the results of the usability test. A paired sample t-test was conducted to determine if a statistically significant difference existed between usability questions from a control group (CG) and experimental group (EG). There was a significant difference in the scores between CG and EG conditions for the measured usability test including *motivating*, CG (M=3.38, SD=1.313), EG (M=4.46, SD=0.658) t(23)=3.680, p =0.001; *engagement*, CG (M=3.38, SD=1.398), EG (M=4.46, SD=0.779) t(23)=2.229, p =0.036 and *learnability* CG (M=3.54, SD=1.382), EG (M=4.42, SD=0.83) t(23)=2.235, p =0.035). Significant results and non-significant results for the usability measures can be found in table 3. The preliminary results of the usability test as hypothesized show that the intervention has a positive effect on motivation, engagement and learning.

Table 2. Paired samples statistics CG vs EG - usability test

Assessment Measure	Mean	N	Std. Deviation	Std. Error Mean
Accessibility EG	4.25	24	0.737	0.15
Accessibility CG	3.46	24	1.179	0.241
Learnability EG	4.42	24	0.83	0.169
Learnability CG	3.54	24	1.382	0.282
Efficiency EG	4.29	24	0.69	0.141
Efficiency CG	3.63	24	1.245	0.254
Satisfaction EG	4.25	24	0.676	0.138
Satisfaction CG	3.63	24	1.209	0.247
Memorability EG	4	24	0.722	0.147
Memorability CG	3.29	24	1.16	0.237
Error Free EG	4	24	0.78	0.159
Error Free CG	2.63	24	1.313	0.268
Manipulability EG	4	24	0.978	0.2
Manipulability CG	3.21	24	1.179	0.241
Navigability EG	4.21	24	0.779	0.159
Navigability CG	3.54	24	1.215	0.248
Visibility EG	4.17	24	0.761	0.155
Visibility CG	3.58	24	1.06	0.216
Real world EG	4.25	24	0.676	0.138
Real world CG	3.46	24	1.318	0.269
Communication EG	4.21	24	0.658	0.134
Communication CG	3.58	24	1.139	0.232
Creativity EG	4.29	24	0.69	0.141
Creativity CG	3.75	24	1.225	0.25
Engagement EG	4.46	24	0.779	0.159
Engagement CG	3.71	24	1.398	0.285
Motivating EG	4.46	24	0.658	0.134
Motivating CG	3.38	24	1.313	0.268

Table 3. Paired sample t-test: control vs experimental group, and p values for significant

Assessment Measure	Mean	Std. Dev	Std. Error Mean	t	p-value
Accessibility	0.792	1.587	0.324	2.443	0.023*
Learnability	0.875	1.918	0.392	2.235	0.035*
Efficiency	0.667	1.606	0.328	2.033	0.054
Satisfaction	0.625	1.439	0.294	2.128	0.044*
Memorability	0.708	1.398	0.285	2.482	0.021*
Error Free	1.375	1.583	0.323	4.256	0#
Manipulability	0.792	1.587	0.324	2.443	0.023*
Navigability	0.667	1.551	0.317	2.106	0.046*
Visibility	0.583	1.442	0.294	1.982	0.06
Real world	0.792	1.769	0.361	2.193	0.039*
Communication	0.625	1.439	0.294	2.128	0.044*
Creativity	0.542	1.56	0.318	1.701	0.102
Engagement	0.75	1.648	0.336	2.229	0.036*
Motivating	1.083	1.442	0.294	3.680	0.001#
*= significance at 0.05 # = significance at 0.01					

4. DISCUSSION

We investigated the impact of presenting a case study using a 360^0 video, supported by using physical objects such as 3d printed tools embedded in a gamified way to assemble a system model. A paired t-test was run to determine whether there were statistically significant usability aspects. These results help determine what are the most important pedagogical advantages of using visual enabled multimodal learning for system modelling, specifically focused on learning use case modelling. Table 2 presents the results of descriptive statistics for the two conditions of the usability measure for the control group and experimental group. The mean of *learnability* measure in the EG is higher compared to the CG, 4.42 and 3.54 respectively. The mean of *engagement* in the EG is 4.46 compared to 3.71 in the CG. The mean of *motivation* measure is 4.46 in the EG and 3.38 in the CG. These above-mentioned results suggest that multimodal information does have an effect when learning. As presented in the results, standard deviation for the learnability, engagement and motivation measures in experimental conditions shows lower deviation results compared to the control condition. Table 3 presents the results of the paired samples t-test of the usability measures. As hypothesized, there was a significant difference in the *p*-value for *learnability* (0.035), *engagement* (0.036) and *motivation* (0.001). These results show statistically significant on the <0.050 alpha. Usability results were also significant for the intervention on accessibility, satisfaction, memorability, error-free, manipulability,

navigability, real world and communication. The nature of the 3d tools can help students with the manipulability, memorability, navigability and communication as it provides an added layer of facilitated interaction for individuals and between students. Positive results on the accessibility and real-world measures can be associated to the visual 360^0 interaction and consequently students' satisfaction, engagement and motivation provides a foundation for learnability. In terms of *efficiency*, *visibility* and *creativity* scores, the *p*-value results indicate that for these measures there is no significant difference between working in a gamified activity or using a traditional learning activity. Lack of efficiency may be due to the piloting nature of this initial loop 1 intervention. Similarly, lack of creativity can be associated with the novelty of this type of intervention. A non-significant result for visibility can be assigned to the lack of a clearer visual introduction and background of the case study.

5. CONCLUSIONS

The use of multimodal learning environments and gamification can be used in ICT system analysis and design to enhance motivation and engagement and learning. These characteristics in conjunction with incorporating 3d printed modelling components can facilitate understanding compared to traditional approaches to teaching modelling. These enhanced interactive activities can effectively increase level of engagement and motivation and create a positive association with learning. Also, the use of 3d printed components can help students to manipulate, navigate, modify and communicate their models

6. ACKNOWLEDGMENTS

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Exploring the Relationship between OJT Course Performance and Academic Performance of Computer Science Students in Selected Programming Courses

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ABSTRACT
This exploratory study attempted to examine the relationship between the level of performance of Bachelor of Science in Computer Science (BSCS) students in their on-the-job (OJT) course and their academic performance in selected programming courses. It also aimed to identify key predictors of OJT performance. The data used in the study included academic and background records of 185 senior BSCS students from the University of the EAST (UE) who were enrolled in their OJT training course during the summers of AY 2014-2018. Data was analyzed in several levels using descriptive and correlational methods using SPSS software. Results indicate a significant and positive but weak relationship between the students' academic performance and their OJT performance. Scholarship status was found to be a more important predictor of OJT performance than academic performance in programming courses. The study, although preliminary, provides valuable insights in the quest to continuously improve the curriculum of the BSCS program in order to provide graduates with the core competencies expected of them in the computing industry.

CCS Concepts
Social and professional topics→Professional topics→ Computing education→ Model curricula

Keywords
On-the-Job Training, Academic Performance, Computer Science

1. INTRODUCTION
The Bachelor of Science in Computer Science (BSCS) program focuses on concepts and techniques used in the design and development of advanced software systems. The goal of the program, among other things, is to prepare students for lifelong learning as they undertake professional careers in computing through the development of necessary skills and critical thinking capabilities in solving a wide variety of problems by applying principles of computational thinking. Programming skill is considered as the key factor in pursuing a Bachelor of Science in Computer Science degree. As part of the BSCS curriculum, students are exposed to various software development and computer programming environments, among them: Visual C++, Java, PHP, Javascript, and MySQL.

On-the-Job (OJT) training plays a vital role in honing the skills, knowledge, and competencies needed for students to succeed in their professional career [1]. OJT is one of the mechanics of the Commission on Higher Education (CHED), the official governing body of higher education institutions in the Philippines, in developing the needed competencies of graduates [2]. CHED Memorandum Order (CMO) No. 25, Series of 2015 defines its goals and objectives as a guide in developing the needed competencies for a particular job and translating students' training into a gainful working experience. As such, CHED mandates higher education industries to strengthen and make more competitive their output and services [3]. This indicates that simply providing knowledge is not enough; students need also to develop insights on how to apply knowledge in a real-life situation [4]. Experiences gained by students from OJT training are essential input to the development of their overall skills as graduates [5].

Generally, companies openly lend a hand in providing students with ample opportunities for OJT apprenticeship, acknowledging that training of future employees is not the sole responsibility of the academe but a shared task with the industry [6]. In addition, many companies consider OJT apprenticeship as part of their human capital investment, and like any investment, they gainfully accept that returns to the cost of these investments will occur in future periods [7].

With these issues in mind, it can be reasonable to assume that the academic performance of students in programming courses have a direct impact on the quality of their performance in their OJT course [8]. Programming courses are designed to hone the logical thinking abilities of BSCS students. More so, these courses provide them with the critical foundational skills needed for independent and life-long learning and prepare them for their careers outside the university [9]. As such, the lack of ample training in programming courses could have a dire effect not only on the prospects of BSCS students as future employees but also with the level of costs that companies would need to shoulder in training them. Despite the potential importance of this assumption, very little research has been conducted that investigates whether or not this assumption is true and to what degree. This study attempts to address this limitation in the current literature by examining the relationship between the students' level of

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performance in their OJT and their academic performance in selected programming language courses. This will help determine the required skill set and competencies that BSCS students should possess prior to graduation. At the same time, analyzing the significant relationship between these variables would identify the importance of theories and knowledge learned from the university which should be applied through practice in the actual workplace.

2. REVIEW OF THE LITERATURE

OJT, like all forms of educational approach, requires a well-organized plan of execution to promote a learning environment where the students' knowledge and skill proficiency can be enhanced. Students can benefit out of the many opportunities that OJT programs can provide. However, students can also encounter uncertainties and problems that in one way or another will affect their performances.

In the past, a number of studies have already attempted to look into the various factors related to students' OJT performance and have focused these studies in various degree programs. These degree programs include BS in Education [10], BS in Engineering courses [9], BS in Hotel and Restaurant Management [3], BS in Mass Communication [11], AB Paralegal [8], and even BS in Information Technology [12]. A critical factor analyzed in many of these studies is the nature of the relationship between academic performance and the performance of students in their OJT. Understanding the correlation of academic performance with the level of OJT performance is critical because it has the potential to inform curriculum developers as well as teachers on how topics in classes should be delivered to enhance both performances [8].

Unfortunately, there are mixed results with regards to the analysis of the nature of these two variables. While in some degree programs, researchers have reported a lack of significant relationship between the performances of students in their major courses and their training performance in OJT [9,3]; there were also degree programs where researchers found students with high academic performance in major courses also obtained high training performance in their OJT and vice versa [11].

Given the perceived importance of the relationship between academic performance and the level of performance in OJT training, as well as the lack of research in this area, the aim of this study was to investigate if such a correlation exists or not within the computer science domain using selected computer programming courses as the focus major courses.

The theoretical and conceptual framework of this study was based on the human capital theory (HCT). HCT, as explained by [13], is a framework that examines the relationships between education and economic growth. A core assumption of HTC is that workers with a higher level of skill receive higher compensation because they are more productive. In line with this study, this theory suggests that the quality of education (e.g., how programming courses are taught) are critical in the process of human capital formation (e.g., BSCS graduates). However, actual productivity in the work environment is a composite of an individual's knowledge and skills as well as personal background and motivations. This study, therefore, attempts to put both sets of variables into consideration. Quality of education was represented in terms of performance in core programming courses while personal background and motivations were defined in terms of background attributes such as age, gender, and scholarship status.

3. PROBLEM STATEMENT

This study aimed to determine the relationship between the level of OJT performance of BSCS students and their academic performance in major computer programming courses. Specifically, the study aimed to answer the following questions:

1. What is the relationship between the students' academic Performance in their programming courses and their level of performance in their OJT course?

2. Which of the attributes incorporated in the study can serve as key predictors of the level of performance in OJT?

3. Based on the findings, what enhancement program can be developed to upgrade and to improve the students' level of performance in OJT?

4. RESEARCH METHODOLOGY

This study made use of the descriptive-correlational research method. This research method is designed specifically to discover relationships among variables and to allow the prediction of future events from present knowledge.

4.1 Procedure

Overall, the generated dataset for this study covered records of all Bachelor of Science in Computer Science (BSCS) students who completed their OJT course in the summer of S.Y. from 2014-2015 to 2017-2018. This includes a total of one hundred and eighty-five (n=185) individual student course records.

Final ratings of the students in their OJT course (CCS 497) was used to represent the level of performance of students in their OJT. This is a composite rating with two components; the first part is the performance assessment of the student coming from the supervisor who oversees the training of the student in the participating firm. This performance assessment was measured and obtained using a standard performance evaluation tool provided by the university which is filled-up by the supervisor after the student has completed the required hours of training (a total of 200 hours with a minimum requirement of 80% completed). The second part consists of the points earned by the student for each OJT requirement submitted to the faculty handling the OJT course at the educational institution. This setup is consistent with the standard OJT course format reported in the literature [14]. Seventy percent (70%) of the final rating for the OJT course is taken from the performance assessment and the remaining thirty percent (30%) is taken from the requirements points.

The academic performance ratings of the students, on the other hand, were obtained from the compiled grade sheets from the College of Computer Studies and Systems (CCSS). In all, this study incorporated in its design variables the final course ratings of the students in the following courses as shown in table 1:

Table 1. Programming courses covered in the study

Code	Course	Description
CCP111	Programming 1	Java Fundamentals
CCP112	Programming 2	Advanced Java Prog.
COO111	OOP Language	VB .Net
CWP111	Web Design 1	HTML5/CSS3
CCP113	Programming 3	C#
CDB111	DBMS	Java
CWP112	Web Design 2	PHP
CSE111	Software Engineering	Software Engineering

Background data variables for each student was also included in the study. The dimensions covered include gender, age, and scholar (i.e., whether or not the student is receiving financial support from the university or other scholarship giving institutions). These data were available from the students' file. Dummy variables for gender and scholar variables were coded as follows: for gender, 1= female and 0=male; for the scholar, 1=scholar and 0=not a scholar. About eight percent (8%) of the students covered in the study were 18 years old; the majority, about seventy percent (70%) were 19-20 years old; and twenty-two percent (22%) were 21 years old or older. Majority of the students were male (71.4%) and the rest were female (28.6%). Only 48 out of 185 or roughly 26% of the students are scholars.

4.2 Data Analysis

The data gathered were first tabulated using frequency counts, mean, and standard deviation to compare the performances of the students in their programming courses and OJT course. Afterward, based on the tabulated data, the correlational analysis was applied to answer Research Question 1. More specifically, through the Pearson Product Coefficient, the degree of association between the OJT course ratings and the academic performance of the BSCS students for each course was described. To answer Research Question 2, the degree of association between the two variables was further assessed by identifying the predictive utility of academic performance by using stepwise linear regression analysis to build a regression model for the level of OJT course performance. Answers to Research Question 3 was discussed in the discussion and conclusions section.

5. RESULTS AND INTERPRETATION

The descriptive statistics shown in Table 2 below, indicate that the computer science students obtained very good performance rating in their OJT course with a mean grade of 1.64. On the other hand, the mean academic performance of students in programming courses ranged from 1.97 to 2.23 indicating a good level of competency in programming and software development.

Table 2. Programming courses covered in the study

Variables	Mean	Std. Deviation	N
OJT	1.64	0.48	185
Programming1	2.23	0.58	185
Programming2	2.02	0.56	185
OOP Language	2.03	0.58	185
Web Design1	1.97	0.52	185
Programming3	1.99	0.58	185
DBMS	2.14	0.51	185
Web Design	2.12	0.52	185
Software Eng'ng	2.12	0.47	185

In total, the academic performances and OJT performance of the students were found to be positively and significantly correlated at $p<0.05$ level of significance except for Programming3 where $p=0.063$. However, the correlation values for these attributes ranged only between 0.137 to 0.258 which can be interpreted as a weak relationship. This finding is indicative of the obscure nature of the OJT training performance and its dependence on many factors outside the programming and system development skills of the students. Figure 1 summarizes the correlations found between OJT performance and other variables in the dataset.

In terms of the regression analyses, to identify the best set of predictors for the OJT performance, a Stepwise Regression analysis was applied. The acquired regression model for OJT performance is displayed in Table 3. As shown in this table, the variable scholar, or the status of receiving a financial grant from the University to support the student's education, was the only predictor selected by the model and accounted for only 7% of the total variance in the level of OJT performance. Since scholarships are awarded on the basis of high scholastic or other exemplary achievements, this result highlights the importance of the student's motivation to learn in general over specific programming skills when it comes to predicting the level of performance in OJT.

Table 3. Stepwise Regression Model for Level of OJT Performance

Model	Variables Entered	R	R2	Std. Error of the Estimate	Sig.
1	Scholar	0.263	0.069	0.46543	.000

The list of variables excluded from the model with their corresponding significance level is shown in Table 4 below.

Table 4. Stepwise Regression Model for Level of OJT Performance

Variables Removed	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
Prog 1	0.13	1.57	0.12	0.116	0.697
Prog 2	0.02	0.22	0.82	0.017	0.656
OOP Language	0.15	1.66	0.09	0.122	0.594
Web Design 1	-0.01	-0.06	0.95	-0.005	0.631
Prog 3	-0.05	-0.51	0.61	-0.037	0.606
DBMS	0.09	0.94	0.35	0.069	0.620
Web Design 2	0.04	0.44	0.66	0.033	0.628
Soft Eng'ng	0.06	0.69	0.49	0.051	0.634
Gender	0.04	0.58	0.56	0.043	0.999
GPA	0.09	0.88	0.38	0.065	0.469

		Programming 1	Programming 2	OOP Language	Web Design 1	Programming 3	DBMS	Web Design 2	Software Eng'ng	Gender	Scholar	GPA
OJT	Pearson Correlation	.238**	.167*	.258**	.156*	.137	.215**	.186*	.199**	.032	-.263**	.235**
	Sig. (2-tailed)	.001	.023	.000	.034	.063	.003	.011	.007	.661	.000	.001
	N	185	185	185	185	185	185	185	185	185	185	185

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Figure 1. Correlations between OJT Performance and other variables in the dataset.

6. DISCUSSION AND CONCLUSIONS

From a literature review and an intuitive assumption, we attempted to test the notion that academic performance, specifically in programming courses, would have significant effects on the level of OJT performance of BSCS students. This is a valid initial perception since programming courses promote the development of higher order thinking skills that are critically needed in computing and other related work. Results of this exploratory study, however, indicated that this was not the case. Correlation analysis not only showed that the academic performance in programming courses are weakly correlated to the students' OJT course rating, but more importantly, regression analysis considers these factors as not contributing significantly to the student's level of performance in their OJT course. Surprisingly, the scholar status of students is the only factor considered in the linear prediction model generated using stepwise regression, overriding the contributions of all the programming coursesand other background variables. This reinforces the fact that industry supervisors and the faculty handling the course do not necessarily assess the students based on their technical programming skills but instead put greater emphasis on personal characteristics. Further research is needed to more clearly identify the components of these personal qualities, but for now, results of this preliminary study provide strong implication towards the development of scholarly attitudes and behaviors among students. These attitudes and behaviors can include notable traits such as motivation to learn independently, confidence, composure, enthusiasm, ability to be a team player, analytical skills, and even foresight [15].

In light of these findings and in answering Research Question 3, it is recommended that the BSCS curriculum be updated to include activities that further hone and inculcate into the BSCS students the notable traits mentioned above. This recommendation aligns with recommendations provided by other researchers in their respective degree programs [16,17, 18, 19]. These activities can include workplace simulation workshops, interpersonal skills training, and personality development seminars that are aimed at preparing the students and help them improve their performance as they experience actual immersion in the industry.

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The Impact of Big Data on Health Care Services in Australia: Using Big Data Analytics to Categorise and Deal with Patients

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ABSTRACT

Big Data is the biggest emerging trend and promise in today's technology-driven world. It is continuing to create a lot of buzz in not only the field of technology, but across the world. It promises substantial involvements, vast changes, modernizations, and integration with and within people's ongoing life. It makes the world more demanding and helps with making prompt and appropriate decisions in real time. This paper aims to provide a comprehensive analysis of the health industry and health care system in Australia that are relevant to the consequences formed by Big Data. This paper primarily uses a secondary research analysis method to provide a wide-ranging investigation into the positive and negative consequences of health issues relevant to Big Data, the architects of those consequences, and those overstated by the consequences. The secondary resources are subject to journal articles, reports, conference proceedings, media articles, corporation-based documents, blogs and other appropriate information. In the future, the investigation will continue by employing Mixed Methodology (Qualitative and Quantitative) in relation to Big Data usage in the Australian Health industry. The paper initially finds that Big Data is an evidence source in health care and provides useful insight into the Australian healthcare system. It is steadily reducing the cost of the Australian healthcare system and improving patients' outcomes in Australia. Big data can not only improve the affairs between public and health enterprises, but can also make life better by increasing efficiency and modernization.

CCS Concepts

• Applied computing→Life and medical sciences→Health care information systems

Keywords

Big Data (BD); Australian Health Care Services; Health Care System; High Risk and High Cost Patients

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1. INTRODUCTION

The Australian health care service is aiming to quickly adopt Big Data, which will significantly increase the quality, quantity, and overall availability of E-data. At the same time, quick improvement has been made in health informatics and analytics by analysing large quantities of data techniques and gathering innovative ideas from that analysis—which is called Big Data.

Extraordinary prospects exist for the use of Big Data to decrease the costs of health care services in Australia. The authors provide some key ideas and opportunities to reduce costs by using Big Data concepts such as "high-cost patients, readmissions, triage, decompensation (when a patient's condition worsens), adverse events, and treatment optimization for diseases affecting multiple organ systems".

The total price of health care services in Australia is significantly high, almost double that in most other urbanized countries, and it continues to rise quickly [1]. It is still unsatisfactory that the National Health Care Act in Australian health care services has been criticized for not doing enough practices to reduce costs [2].

One massive success of Australian health care services is the quick implementation of E-Health Records (EHRs). The evolution of EHRs makes it imaginable to access E-data and offers the prospective for budget funds [3]. But unfortunately, high expenses and access to patients' records by health care service providers are as yet uncertain and questionable [4].

Many ICT specialists have called for health care services in Australia to accept Big Data methodologies, but compared to other industries such as ICT, property, logistics, E-business etc., the Australian health industry is still far behind, and thus far, relatively limited at using Big Data to advance productivity and competency [5] [6]. Therefore, the health care service organizations in Australia must organize more active use of Big Data Analytics.

In an ideal situation, Big Data Analytics involves relating data from numerous fields with medical, genetic and genomic, results, entitlements, and public data [7].

Big Data Analytics can offer many analytic approaches including pattern recognition, natural disease processes, probable expensive outcomes accompanying a patient's injury, high-cost patients, readmissions, triage, decompensation, adverse events, and treatment optimization for diseases etc.

Below, the authors have addressed different data types and setups that health care services in Australia will use in future. The

authors have also discussed how health care services in Australia can perform to a much higher standard in the future.

2. LITERATURE REVIEW

2.1 High-Cost Patients

One of the most effective Big Data Analytics approach is to reduce high costs and improve their care by identifying high-cost patients and managing them more successfully. This kind of approach can be used to reduce the high cost [8]. In relation to identifying actual patients and implementing Big Data analytic methods, the authors have considered several issues. Firstly, what tactic should be used to monitor high danger patients and/or who are the high-cost patients? Secondly, how should we improve measurements and predictions of health care? Thirdly, identifying multiple characteristics connected with high-cost patients, but not limited to intellectual disability, mental health problems, behavioural health problems or socioeconomic problems such as poverty, domestic violence, cultural pressure, marital and living issues etc. Fourthly, in order to make all the predictions happen, it is necessary to modelling population management, identifying the most benefits for, and improving health care services in Australia. The Australian enterprises that presently use Big Data Analytic systems have focused on identifying processes that can best arrange data by risk of future high possible costs. The distinction between processes may not be enormous, and a more applied process will be the healthier one. Processes can help to do transformation possessions more fruitfully at a range of risk levels [9] [10].

In addition, the authors have suggested that it is vital to use Big Data analytic systems to find out potential high expense dealing patients to control their necessities in the health care sector. It is particularly important to categorize and report behavioural health problems, medication nonadherence, family conflict, and mental problems such as depression and stress [11].

2.2 Medical Admissions & Readmissions

Public and private hospital admissions and readmissions have high cost [12], though the Australian Government-Department of Human Services, particularly Medicare Australia, has presented significant opportunities for improving health care delivery [13]. Big Data can play a key role in medical work and forecast about the admission and readmission to the community or private hospital. It helps in estimating the risk of complications, making sure that patients receive the best health care services and monitoring special patients who have received additional advice by making calls or sending e-mails after discharge from the hospital.

2.3 Priority of Patients' Treatments

Big Data can play a key role in managing facilities and resource allocation, handing over patients to an appropriate place, and the overall management of a patient. In the anti-natal and post-natal setting, Big Data Analytics helps to capture a patient's physiological instability, revolutionize the management of newborn resuscitation, evaluate newborns, take physiological measurements, make accurate health assessments, capture data after a patient who is critically ill has entered the Intensive Care Unit - ICU or has been hospitalized, provide comprehensive information, and aid in the delivery of an overall integrated health care service [14] [15].

3. RESEARCH METHODOLOGY

This paper examines the characteristics of IT emerging technology related with health informatics, and health organizational and environmental factors that impact the acceptance of Big Data services.

3.1 Identification of Scope of Study

To accomplish the paper objectives, an organized process is followed. The process begins with the identification of the project topic where studies are carried out to obtain enough information on the topic.

3.2 Discussions to Collect Suggestions on Big Data in Australia

Discussion is made between authors about the topic, the impact of Big Data on the Australian health industry, the barriers to implementing Big Data in Australia, and the future of Big Data.

3.3 Online Review to Collect Data on Big Data

Authors have searched and collected data about Big Data business growth and the present situation of Big Data in Australia.

3.4 Research and Review

This paper also analyzes secondary academic resources from peer reviewed papers, academic proceedings, local and international journals, periodicals, articles, and corporate annual reports.

3.5 Interviews to Find Out What People Think about Big Data

Authors will conduct future potential interviews with IT experts, government and non-government officials, IT students, and university academics of Australia. Authors will also discuss with them the benefits and risks of Big Data, the past and current situation of Big Data, privacy and security satisfaction in Australia etc.

4. RECOMMENDED STRATEGIES BASED ON RESEARCH FINDINGS

4.1 Decompensation

According to Google Dictionary, "Decompensation is the failure to generate effective psychological coping mechanisms in response to stress, resulting in personality disturbance". Big Data can find out whether the patient is in real danger of decompensation. Big Data Analytics can offer a host of technologies including electrocardiographic monitoring, CO2 and O2 monitoring, medical background checks, and screening for decompensation [16]. It can screen patients who stay in general care, in care centres or even in the Intensive Care Unit -ICUs of Australian Public and Private hospitals [17-19].

4.2 Aggressive Events

Big Data Analytics can predict the patients which are at risk of hostile events or aggressiveness of several types. Hostile events are exclusive [20] and cause considerable sickness.

4.3 Renal Failure

Big Data Analytics can identify patients at high risk of decompensation, monitor kidney function, blood pressure, urine output, and advise specific medications where necessary [21].

4.4 Pollution

Big Data Analytics can be effective in managing infection. It is a sophisticated analysis which closely screens heart rate, detecting very low birthweights etc [22].

4.5 Hostile Drug Events

Big Data Analytics have the probability and possibility to forecast with considerable accurateness which patients may have the highest possibility of suffering a hostile treatment event, and to classify early staged medical patients, by evaluating particular evidence, workshop figures, and other relevant data [22].

4.6 Diseases Affecting Multiple Organ Systems

Big Data Analytics and clinical data networks play vital roles in registering chronic conditions and diseases such as "skin, mucosal, renal, musculoskeletal, pulmonary, haematological, immunological, and neurologic manifestations, Autoimmune disorders such as scleroderma, rheumatoid arthritis, and systemic lupus erythematosus and in improving care for patients with such diseases" [23]. It also helps to do a successful repetitive care to conclude advancement of illness and adapt treatments [24, 25].

4.7 Discussion

The authors have discussed various issues where Big Data Analytics are extremely advantageous and applicable for high-risk patients. The evidence of benefit and the recent costs for the patients in health services are actually exceptional [24, 25].

The authors [24, 25] have concentrated particularly on a few sectors such as some local based Public and Private Hospital settings where the most data are available, the health care services variety, assessment of the inclusive drivers of costs, using clinical tools, identifying different types of diseases, patients with high costs, patients' admission and readmission in hospitals or clinics, management of patients etc. Much of the focus of Australian health care service organizations in Big Data Analytics in health has been on patients. This approach can frequently be active. However, the authors believe that multiple conditions-based approaches can better control health care outcomes and cost savings in the long term [25].

4.8 Disbursement and Compensation

With respect to payments, health care strategies should encourage enterprises to advance in cost reduction so that it will help to speed up the adoption of Big Data Analytics [26].

4.9 Privacy & Security Satisfaction

Regarding privacy and security consideration, there are many ongoing issues in Australia. In general, people do not wish to share personal data which may have a close or overall average connection with other data. On the other side, medical data are even more complex compared to other data. Predominantly in a health care system, patients have a privacy concern and ethical commitment to contribute to the general determination of enlightening the excellence and worth of health care in Australia [27]. However, even Australian Policy makers have very little interest in dealing with possible changes to the Health Information Act, Rules and Regulations and any main Legislation connected with privacy and security satisfaction in health care services.

4.10 Prospective Research

In relation to conducting future research, more logical evaluations should be mandatory for the investigation to be more effective and efficient. Precisely, the authors strongly believe that Australian Local and Federal Government support for future research is a must in order to evaluate the use of Big Data Analytics, and to address the issues in Health care services more proactively such as the practice of medical sensor technologies, therapy selection for high-cost patients, and organ systems etc. In this case, due to the comparative significance of developing specific approaches, the traditional approach and high-tech approach (e.g Data Mining) [27] will be more applicable.

The existing findings offer a basic clear understanding of Big Data innovation, scientific, enterprise oriented and user-friendly factors and overall Big Data adoption within the Health service industry. The paper establishes that Big Data services are advantageous and central technology tools. Based on this concept, primary recommendations have been outlined for both practical use and future research, and future recommendations will be delivered.

Primary recommendations are derived from secondary research analyses including a literature review, and will be further derived from the analysis of future surveys & interview data. The comparison and crosscheck between the data gathered from the secondary research analysis and the future data collection from mixed research methodology will help to validate and enrich the research findings.

The Australian health sector can use a Big Data framework for accessing medical applications, processing patient's admissions and readmissions, developing a medical business architecture, establishing medical cost and governance, providing artificial intelligence and machine learning, and business scalability of Big Data Analytic services. The authors have considered security and privacy satisfaction as one of the key factors for Big Data adoption. Strong architectural design, back up security policy practice, and flawless calculation of costs are must going issues for business continuity with Big Data.

Big Data can play a very vital role in the Australian Economy and overall Gross Development Product-GDP. Big Data will help Australian Health industries to become more effective and to make positive contributions to the local and national economy.

The health sector is an essential sector in under-developing, developing and developed countries as they contribute substantially to the nation's economy and GDP, and influences the economy significantly. Offering new techniques and technologies, like with Big Data, which assist the health sector in an emerging and effective way has a significant impact on the entire financial system. In this instance, the Australian government needs to be more promising in designing rules, regulations, policies and procedures for Big data adoption and implementation.

This paper has produced awareness about the application of Big Data services throughout the health sector in Australia. Further, it has provided the concept of Big Data adoption. This paper clearly has suggested that there are further positive, effective and efficient contributions required by the Australian Local and State Government.

The academic personnel can contribute significantly to this sector by developing literature and better practices on Big Data service adoption.

5. CONCLUSIONS

Big Data Analytics is a commanding tool that is very advantageous in Australian health care services, as well as in other sectors. Big Data analytics are of the greatest value for health care service organizations. This method has significant potential for improving the value of Australian health care services. The company which employs Big Data in many areas will be at a significant advantage.

The authors make clear suggestions that the Australian Local Government and State Government need to provide full comprehensive support to adopt Big Data in health care industries. Some effective suggestions are offered with some proactive steps for ensuring efficient movement to the Big Data environment. Other Researchers and Research organizations should step forward and concentrate more on Big Data approval within the Australian health industry sector. The strong and effective participation of the stakeholders on research areas will further encourage Big Data adoption among health industries. It will also help in improving economic stability throughout Australia.

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Comparison of Effectiveness between Contextual Teaching and Learning (CTL) and Problem-Based Learning (PBL) Approach on the Interest of Junior High School Students

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ABSTRACT
The purpose of this study is to reveal the effectiveness of contextual teaching and learning (CTL) and problem-based learning (PBL) approaches on students' interest. This study was quasi-experimental research with pretest-posttest group design. The population of this research was all students of grade VIII of State Junior High School 9 Yogyakarta. Then, the sample involved 34 Junior High School students in each class that has been taken using purposive random sampling. The first experiment class used Contextual Teaching and Learning (CTL) approach, and the second one used the Problem-Based Learning (PBL) approach. The instrument was the interest questionnaire which was given to the students before (pretest) and after treatment (posttest). The data were analyzed using one sample t-test with a significance level of 5% to find out the effectiveness of CTL and PBL approaches on students' interest. Then, the data were analyzed using independent sample t-test to compare the effectiveness of both approaches. The results showed that both CTL and PBL methods were effective in terms of students' interest mean scores. The comparison result demonstrated that CTL was more effective than PBL to improve the interest of junior high school students.

CCS Concepts
• Social and professional topics→Professional topics→Computing education→Student assessment.

Keywords
Contextual teaching and learning, problem-based learning, students' interest

1. INTRODUCTION
Learning process is one of important thing in the school activities. But, there are still many problems in the learning process, one of which is the weak teaching and learning process. In the learning process today, students less encouraged to develop thinking skills in problem-solving and apply their ability to their daily life [1]. The students are forced to remember various information without understanding the information they remembered and connect to their daily life. So, it makes a lack of students' interest to learn mathematics [1].

To many psychologists, interest is a vague, everyday term that denotes a personal characteristic or an effective state and that has already been thoroughly investigated by modern motivational psychology [2]. Deci and Ryan define interest as an important directive role in intrinsically motivated behavior in that people naturally approach activities that interest them [2]. Interest is one of the primary goals of education because of it closely related to learning. Interest allows for correct a complete recognition of an object, leads to meaningful learning, promotes long-term memory of knowledge, and provides motivation for further learning [2].

Learning interest could most probably be a very strong affective psychology and strong knowledge. It is also as a magnetic positive feeling, a sense of being captivated, enthralled, invigorated and energized to cognitively process information. The information process becomes faster and more accurately in addition to the most effective application of psychomotor traits like self-regulatory skills self-discipline, working harder and smarter with optimum persistence [3]. Interest has characteristic that might have a big influence on educational and occupational achievement, interpersonal relations, leisure activities, and other daily life activities [3]. Isangedighi said that there is a strong correlation between interest, study habits and academic achievement of high school students [3]. It is also proved that interest has an effect on the learning process and outcome.

The lack of students' interest in learning mathematics is one of problem must be solved by the teachers. Based on the problem above, a good learning approach is needed to improve students' interest. Contextual Teaching and Learning (CTL) and Problem Based Learning (PBL) are two learning approaches that can be used as an alternative to improve students' interest. CTL can help students to connect the content they are learning to the life contexts in which that content could be used [4]. So, CTL is considered appropriate to improve students' interest because it helps students to apply their ability to daily life.

A preliminary definition of Contextual Teaching Learning (CTL) emerged from projects sponsored by the Office of Vocational and Adult Education, U.S. Department of Education. Then, the two

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universities that are Ohio State University and Bowling Green State University utilized this funding to study CTL. From this partnership of both university, they developed the following definition of CTL: Contextual Teaching and Learning is a concept of teaching and learning that helps teachers relate subject matter content to real-world situations; and motivates students to make connections between knowledge and its applications to their lives as family members, citizens, and workers; and engage in the hard work that learning requires [5]. CTL is an approach that helps students to discover the concepts of material through to knowledge and experience of the students [4]. CTL also involved students to be active in the learning process.

There are seven components applied in CTL approach to make an effective teaching and learning process [4]. The components can be described as follows:

1. Constructivism is the philosophical thinking of contextual teaching and learning.
2. The inquiry is the core of teaching and learning activity in CTL where students active to develop concepts by themselves.
3. Questioning is one of the students' processes to construct concept and knowledge.
4. Learning Community. Based on this component, students' can construct their knowledge well by social interactions.
5. Modeling that given by the teacher or the other students is better in construct students' concept.
6. Reflection is how to think what has just been learned and how students' response to events, activities or knowledge that students have learned or mastered in the past.
7. Authentic Assessment is the process of gathering data to give a description of students' learning development.

CTL can help students to connect the content they are learning to the life contexts in which that content could be used [4]. Annisa said that CTL is the concept of teaching and learning that help teachers relate subject matter content to real-world situations and motivates students to connect between knowledge and its application to their daily life [6]. Thus, based on several definition above, it can be concluded that CTL is an approach that helps teacher to connect the material to daily life situations, motivate students to make connections between knowledge and its applications to their lives as family members, citizens, and workers, and help students to discover the concepts of material through to knowledge and experience of the students.

Problem-Based Learning (PBL) began at McMaster University Medical School over 25 years ago. Additionally, elementary and secondary schools have adopted PBL approach. PBL describes a learning environment where problems drive learning [7]. Barrows and Tamblyn said that PBL is the instructional method in which students learn through solving problems and reflecting on their experiences [8]. PBL is described as a learning approach where problems drive the learning where learning begins with a scenario carrying a real-life problem to be solved. It means that students need to solve by means of the knowledge and required information they have already acquired.

Problem-Based Learning is a learner-centered pedagogical approach that affords learners (including prospective and certified teachers). Students or learners also work independently to collect information they need then bring back to the group as they resume their collective problem solving and subsequent reflection on both the issue at hand and the groups' functioning. The aim of using PBL is to conceptual and pedagogical content knowledge construction, collaboration, and self-directed, lifelong learning [9]. Based on this aim and definition, PBL can be an alternative to be implemented to improve students' interest because it can develop their thinking skill in problem-solving.

Sluijman said that knowledge must be constructed by the students and it's not to be expected that the knowledge given only by the teacher. Students become a good problem solver by using their thinking skills at the top-level after they doing the process [10]. Real-world problems were used in learning as a context for students to learn about problem-solving skills [11]. There are 6 characteristics of PBL as follows: 1) concrete problems are used to begin the learning process in the class; 2) the important thing in the learning process is how to attract students' attention, so the materials and activities must be created attractively; 3) teacher is a supervisor or facilitator during the learning process occurred; 4) students need to be given enough time to think or collect information and develop strategies for problem-solving and creativity they have driven while learning; 5) the level of difficulty of the problem and materials given to the students are middle rates which can make students attract and don't make students despair; 6) teacher must help students to develop their abilities well by creating a comfortable, conducive and safe learning environment during learning process [11].

Students' interest in learning mathematics will determine the responses to be given by these students about things that related to mathematics learning. Students who have a high interest in learning mathematics will tend to give a positive response to learning mathematics. They will tend to have an initiative and willingness to learn mathematics deeper and achieve good results in mathematics [12]. PBL approach has been proven can reduce students' misunderstandings and misconceptions of mathematics. Then, studies before has been proven that PBL is also more effective than traditional methods in teaching mathematics [8]. Moreover, relevant studies by Laili indicated that CTL and PBL approaches were effective to improve students' motivation and achievement in mathematics learning [1]. This study also supports the theory of both approaches that showed a positive influence when applied in the learning process. CTL approach through REACT strategies was effective to improve students' critical thinking skill [13]. Based on this background and relevant studies, this study was conducted to compare the effectiveness between CTL and PBL approach on students' interest.

2. RESEARCH METHOD

This research was a quasi-experiment design. The researcher cannot choose the students randomly, so it only used classes in Junior High School. Class VIII B was chosen to be the first experiment class using CTL approach, and VIII C was the second class using a PBL approach. Both of these classes were given interests' questionnaire before and after the treatment applied. The teaching aid in this research was the lesson plan, students' worksheet, and interest questionnaire.

In this research, data were collected directly by giving treatment to both classes. The data collecting technique used was the questionnaire as a non-test instrument to know students' interest that given before and after treatment. The instrument must be analyzed the validity and reliability first. The validity of the instrument used was the expert judgment and the reliability test used was Cronbach-Alpha reliability index.

The purpose of this research was to investigate the effects of Contextual Teaching and Learning (CTL) and Problem-Based

Learning (PBL) approaches on students interest. Then, both methods are compared to find out which was more effective in increasing interest. The study was restricted to 68-second grade junior high school students that divided into 2 classes. The duration of collecting data was limited up to three weeks consist of 6 meetings including filling out the questionnaire in the beginning and ending of the research.

Participants of the research consisted of 68-second grade students at State Junior High School 9 Yogyakarta, Indonesia. There were two classes as an experimental class, so each class consisted of 34 students. Contextual teaching and learning (CTL) was used in the first class and the second class was given by a problem-based learning (PBL) approach.

In this research, the questionnaire which was developed by the researchers to determine the students' interest in learning mathematics. The questionnaire used a Likert scale with 5 options answer namely always, often, sometimes, rarely, and never. Students responded questionnaire by giving a checklist to the answer column provided. In the questionnaire, there were positive and negative statements. The researcher developed the questionnaire using 4 indicators based on the definition of interest. These indicators were distributed to the 27 questionnaire statements. This 27 statements are divided into 2 kind statements that are 15 positive statements and 12 negative statements. These two kind statements are presented in questionnaire randomly to know students' consistency in giving their responses. There are 5 kind answer in the questionnaire (always, often, sometimes, rare, and never) and 5 scores based on positive and negative statements. The maksimum score is 135 and 27 for minimum scores.

The total score of each respondent will be converted into 5 categories based on the formula shown in Table 1 [14].

Table 1. Interval Conversion of Interest Questionnaire

Score Interval	Categories
$x > \bar{X}i + 1{,}8\ Sb_i$	Very High
$\bar{X}i + 0{,}6\ Sb_i < x \leq \bar{X}i + 1{,}8Sb_i$	High
$\bar{X}i - 0{,}6\ Sb_i < x \leq \bar{X}i + 0{,}6Sb_i$	Medium
$\bar{X}i - 1{,}8\ Sb_i < x \leq \bar{X}i - 0{,}6Sb_i$	Low
$x \leq \bar{X}i - 1{,}8\ Sb_i$	Very Low

Based on Table 1, the effective learning process occurred if 75% or more students have questionnaire total score at high and very high categories. Before the questionnaire is used to collect the data, it is tested on students to find out the reliability of the item. By using SPSS, the reliability test's result can be seen in the Table 2.

Table 2. Reliability Statistic

Cronbach's Alpha	N of Items
0.861	27

Based on Table 2, Cronbach alpha index 0.861 is more than 0.6, so all of questionnaires' items were reliable. Then, one sample t-test used using SPSS application to know the effectiveness of CTL and PBL learning approach on students' interest. The formula of one sample t-test can be shown as follows.

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}}$$

$\bar{x}$ = means of sample
μ_0 = hypothesis score
s = standard deviation
n = number of sample

Based on this formula, the learning approach is effective if significant value of t-test less than alpha (0.05).

After analyzing the effectiveness of CTL and PBL approach in each class, this research also conducts the next step to know the comparison between CTL and PBL toward students' interest. Before comparing both of approach, the prerequisite test must be analyzed from the data namely distribution normality and homogeneity test of variances. Distribution normality test in this research was a one-sample Kolmogorov-Smirnov test calculated using SPSS and homogeneity of variances used was Levene Statistic. The data have normal distributions and homogenous variances if the output of SPSS shows significant value more than alpha (0.05).

If the normality and homogeneity test are completed, the next analysis is t-test for equality of pretest means score of both classes to know the difference of initial ability. If both of class have equal means, the next analysis is to know the effectiveness of each approach. Post-test score of students' interest are used to know the effectiveness of each approach by using one sample t-test. After knowing the effectiveness of both approaches, the last analysis is to compare equality of means between the interest score after the treatment applied to both of class. This analysis was done if the previous analysis shows that both CTL and PBL class are effective to improve students' interest. To compare the effectiveness of both class, independent sample t-test was used. CTL is more effective than the PBL approach if significant value less than alpha (0.05) and vice versa.

3. RESULT

Instruments that have been developed by researchers then are given to the students before and after the treatment implemented. Before the treatment, the initial score is used to know students' interest before treatment, then the score after the treatment is used to know the improvement and effectiveness of both approaches. First, the data isanalyzed to know the descriptive statistic result. Before analyzing it, calculations' result of means' conversion formula was completed first. The result can be seen in Table 3.

Table 3. Conversion Means Score of Interest

Score Interval	Categories
$x > 113$	Very High
$91 < x \leq 113$	High
$70 < x \leq 91$	Medium
$48 < x \leq 70$	Low
$x \leq 48$	Very Low

Based on Table 3, CTL and PBL approach effective to improve interest if there is a significant difference between the scores before and after implementing both approaches in each class. Meanwhile, the minimum means score of post-test must be at high categories ($91 < x \leq 113$). After implementing CTL and PBL approaches, the descriptive statistic result of students' interest were summarized in Table 4.

Table 4 gives information that interests' score means both of class improve after giving treatment. Before treatment, means' score of both classes still in the medium category based on Table 3. Meanwhile, after the treatment is used, the score shows improvement to high category. Table 4 also shows that CTL class has a higher score than the PBL class. Before making a statistical analysis, the data was identified whether it had a normal distribution or not. The normality test used one-sample Kolmogorov-Smirnov test and the result is summarized in Table 5.

Table 4. Students' Interest Data

Deskription	CTL Class		PBL Class	
	Pre-test	Post-test	Pre-test	Post-test
Means	88.47	104.20	89.91	97.71
Standard Deviation	10.00	12.84	16.04	14.78
Ideal Minimum Score	27	27	27	27
Minimum Score	66.00	80.00	64.00	62.00
Ideal Maximum Score	135	135	135	135
Maximum Score	116.00	124.00	130.00	125.00
Variants	100.13	164.89	257.9	189.45

Table 5. Result of Normality Test

Sort of Test	Respondents	Mean	Sig. (2-tailed)
Pre-test CTL Class	34	88.47	0.20
Pre-test PBL Class	34	89.91	0.15
Post-test CTL Class	34	104.20	0.10
Post-test PBL Class	34	97.11	0.20

Based on the result, all sig. of the data is more than alpha (0.05). Henceforth, it can be concluded that the data distribution is normal. After the data have a normal distribution, pre-test score of CTL and PBL class was analyzed to know the homogeneity of variance. The result of the homogeneity test is presented in Table 6.

Table 6. Homogeneity of Variances Test

Levene Statistic	Sig.
3,684	0.059

The result shows that significance is more than alpha (0.05), so it can be concluded that the CTL and PBL class have homogenous variance. Then, the result of means equality test of pre-test score can be seen in Table 7.

Table 7. Result of Means Equality Test

Score	Df	Mean Difference	Sig. (2-tailed)
Pre-test Scores	66	-1.44	0.658

Table 7 shows that significant value of the test was more than alpha (0,05), so it can be concluded that students' interest before treatment is same or there are no significant difference means of both classes. Then, before comparing the effectiveness of CTL and PBL approach, the data were analyzed to know the effectiveness both of approach toward interest. So, the post-test score of interest must be analyzed to know the effectiveness of both classes using one sample t-test with test value 91. The result can be seen in Table 8.

Table 8. Result of One Sample T-test of Post-test Score

Score	Df	Mean Difference	Sig. (2-tailed)
CTL Class	66	13.20	0.000
PBL Class	66	6.11	0.022

Table 8 shows that significant value of CTL score post-test is 0.000 that less than alpha (0.05). It means that CTL effective to improve student interest in learning. Then, the result of one sample t-test PBL class also shows that the significant value is 0.022 less than alpha (0.05). So, it can be concluded PBL approach also can improve students interest in learning mathematics.

After analyzing the effectiveness of each approach, the next is data analyzed to compare which one is more effective. To determine which approach is more effective, independent sample t-test is used to know the means difference of both classes. The result is presented in Table 9.

Table 9. Result of Independent Sample T-test

Score	t	Df	Mean Difference	Sig. (1-tailed)
T-test for Equality of Means	2.11	66	7.08	0.0195

Based on Table 9, the significant value was less than alpha (0.05) so H_0 was rejected. it can be concluded that the CTL approach was more effective to improve students interest than the PBL approach.

4. DISCUSSION

Based on the score before the treatment was used, the experiment classes were slightly at the same level and both classes achieved 88.47 and 89.91. The different treatment was conducted for both classes. CTL approach through REACT strategies was treated in the first class and PBL approach was used in the second class. The questionnaire was given to the students again after the treatment. Afterwards, this score was analyzed to know the effectiveness and to compare both of approach.

Finally, based on the statistic analyses, CTL and PBL approach could improve students learning interest. The result also supported in t-test analysis that showed a significant difference in students' post-test score. This result are also linier with the studies conducted by Laili, Kazemi, and Chrissanti [1,8,12]. If it looks from the post-test score, CTL class showed a higher score than PBL class with 6,49 difference point. Based on the independent sample t-test also prove that CTL approach was more effective than the PBL approach to improving students' learning interest.

CTL approach is more effective than PBL approach because when learning process occured, students more interested and enthusiastic when they know the role and benefit of mathematics in their life. REACT strategies also made students active to discuss their problems in each group. CTL also helps students made the material they learn more concrete. This condition was proven to be able to increase interest and more effective than PBL approach. So, based on the theory and learning process in the class, students' interest in the CTL class was better than the PBL class. It is also supported by the analysis.

5. CONCLUSION

Based on the results of research and discussion presented, it can be concluded that both CTL and PBL approach can improve students' interest. Connecting material with daily life in CTL approach and practice solving problem in PBL are proven to improve students' interest. Then, the comparison result demonstrated that CTL is more effective than PBL to improve the interest of junior high school students.

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Self-Directed Learning of Student in Mathematics Education: Is There Any Problem?

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ABSTRACT
Self directed learning is an awareness by individuals to gain knowledge with or without encouragement from others. There are several components of self directed learning which are related to Leaning motivation (LM), Planning and Implementing (PI), Self-monitoring (SM) and Interpersonal communication (IC). This research was conducted on 129 junior high school students. Then data obtained were processed quantitatively and explained in detail from the tables obtained. As for the results show that students still have problems in their self directed learning. So that efforts are needed to improve these capabilities.

CCS Concepts
• Social and professional topics→ Professional topics→Computing education → Student assessment

Keywords
"Self Directed Learning, Leaning motivation, Planning and Implementing, Self-monitoring, Interpersonal communication"

1. INTRODUCTION
Learning is a facility to get repairs and facilitation in life. But learning is approved, not only the knowledge gained from a teacher for his students. However, more than that, people must arrange and obtain knowledge by using it himself, through experiments conducted [1]. This is expected that the knowledge obtained can be more and accepted for. This opinion is supported by Bruner's statement which states that experience is an essential thing that must exist in learning [2]. Nevertheless, there are several concepts that cannot be accessed directly by students and there must be assistance provided by the teacher or more in Vygotsky's theory better known as scaffolding.

Scaffolding is total help for students to learn and do problem-solving. The assistance provided is varies. It's Can be in the form of instructions, encouragement, approval, giving examples, and other actions that allow students to learn independently [3]. Independence in learning can arise if students have a large self-directed to learn. Self directed learning can help the learning process of others, learn to help others, learn the needs in learning, formulate learning, identify the material and the ability to learn, choose and apply strategies that are in accordance with the results of learning done [4]

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The opinion also supported by Brockett stated that self directed learning involves involving in learning activities, where individuals responsibly develop and learn to learn independently without assistance or guided by others, such as teachers, parents or peers [5]. Students who have the ability to learn independently must have the willingness to learn more as in the course and demand that they achieve higher achievements [6].

Research conducted by Zhoc & Chen, they concluded that self directed learning is highly positively correlated with regulation of optimism, logistical training, renewal and social training [7]. In addition, according to Lounsbury, J. states that there is an affirmative relationship between self directed learning and academic achievement and experience in universities (place of learning) [8]. Somewhile, the teacher is often mistaken in assuming that students have directed learning skills or assume that students will develop these abilities when they are in an environment that requires them to direct their own learning [9]. Though, Self-directed learning skills must be trained in every learning process. Therefore, it is not surprising if students are now directed to be more motivated and open to obtain independent learning practices. The importance of students' in self directed learning makes researchers interested in studying more about how students are independent in learning, especially in mathematics. The researches also want to find an illustration of whether there are the difficulties of students in self directed learning that looking to each component of self directed which is manifested in the low scale value of these components. By knowing the difficulties experienced by students, the teacher can provide assistance in accordance with students difficulties.

2. RESEARCH METHOD
This study used 129 eighth grade junior high school students as research subjects, which came from 4 different classes, namely classes A, B, C, and D. The data in this study were obtained through student self directed learning questionnaires that adaptation of the instrument used by Shen, Chen & Hu [10], in his research entitled *The Validity And Reliability of Self-Directed Learning Instrument (SDLI) In Mainland Chinese Nursing Student.* The instrument was modified and adapted to the needs of the researcher with regard to mathematics. The data obtained is processed deskriftif quantitative. The data obtained is spelled out based on the results of the questionnaire that has been tested.

The questionnaire consists of 15 positive statements outlined from the 4 components of self directed learning, which is related to Leaning motivation (LM), Planning and Implementing (PI), Self-monitoring (SM) and Interpersonal communication (IC). In the questionnaire students are asked to choose one of the 4 answer

columns provided with SS details (always): if you always do according to the statement; S (often): if you often do according to statements and sometimes do not do; K (sometimes): if you sometimes do and often do not; TP (never): if you never do. After the data is obtained, the data is processed by giving different points for each answer, namely SS: 4 points, S: 3 points, K: 2 points and TP: 1 point. The instruments used are as follows:

Table 1. Instrument of self-directed learning

No.	Statement	Categories
1.	Regardless of the value obtained, I still like to study mathematics.	Learning Motivation (LM)
2.	I really hope to be able to continue to improve my mathematics learning outcomes.	
3.	I will not give up studying mathematics even though I face some difficulties.	
4.	I want to ask for help from others to achieve my goals when studying mathematics.	
5.	I know what learning strategies are right for me in achieving math learning goals.	Planning and Implementing (PI)
6.	I set priorities in learning mathematics.	
7.	I am good at managing time to study mathematics.	
8.	I know how to find additional mathematics learning resources.	
9.	I can connect new knowledge in mathematics with my own personal experience.	Self-Monitoring (SM)
10.	I continued to monitor the progress of learning in mathematics.	
11.	I understand my strengths and weaknesses in learning mathematics.	
12.	I can evaluate my own learning outcomes in mathematics.	
13.	My interactions with others helped me plan further mathematics learning.	Interpersonal communication (IC)
14.	I can communicate effectively in oral mathematical presentations.	
15.	I can communicate mathematical ideas effectively in writing.	

The next step is to determine the category using the Likert scale for each subject for students' self directed learning with 5 categories Very High, High, Medium, Low, Very Low. Determination of categories follows Widoyoko's opinion [11], as follows:

Table2. Table of skor categories

Interval	Categories
$X > \bar{X} + 1{,}8\ Sb_i$	Very high
$\bar{X}_i + 0{,}6\ Sb_i < X \leq \bar{X}_i + 1{,}8\ Sb_i$	High
$\bar{X}_i - 0{,}6\ Sb_i < X \leq \bar{X}_i + 0{,}6\ S©b_i$	Avereage
$\bar{X}_i - 1{,}8 Sb_i < X \leq \bar{X}_i - 0{,}6\ Sb_i$	Low
$x \leq \bar{X}_i$ -1,8 Sb_i	Very Low

Information:
X: empirical score
$\bar{X}_i$: Standar deviation
Sb_i: deal standard deviation
The data obtained are then analyzed descriptively to see which part of the self directed learning component of students is still problematic. The hope can be an information for teachers about the self directed learning of student, and find solutions to help increase of student self directed laening.

3. RESULT AND DISCUSSION

self directed is obtained from 4 different classes, which have diverse or homogeneous academic abilities with 129 students. In general, data is obtained as in the following table:

Table 3. Table result of student self-directed learning

Categories	Quantity Of Student	Quantity Of Student (IN %)
Very high	2	1,55
High	46	35,65
Avereage	77	59,68
Low	4	3,10
Very Low	0	0,00

From the table, it can be seen that 1.55% or only 2 students who have to learn self directed in the very high category. This is the initial foundation that illustrates that the self directed of student learning needs to be improved. In the High category, 35.65% or there are 46 students who have to learn self directed in the High category. This percentage is still far but almost half of the research subjects have high of self directed learning. Furthermore, for the Medium category of more than 50 percent or more precisely 59.68 percent of students have standard of self directed learning, neither high nor low. Although this result is not so disappointing, it still requires encouragement to help students improve their self directed learning. In the Low category, 3.10% or there are 4 students who have self directed learning categorized as low. This means that these 4 students have problems related to Leaning motivation (LM), Planning and Implementing (PI), Self-monitoring (SM) and Interpersonal communication (IC). Last, in the category of Very low, there is no one of student in this category, this means that problems related to student self directed learning are very likely or have a great opportunity to be overcome.

The entire component of student self directed learning illustrated above can be represented in the following chart:

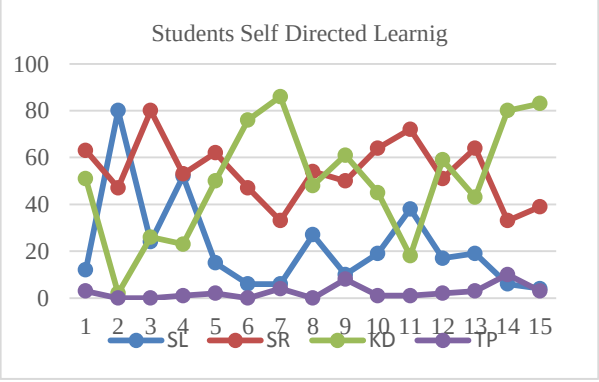

Figure 1. Chart of student self-directed Learning

If viewed in outline, the category or number of students in each category is not too alarming. However, to find a solution to the problem of student self directed learning above, we need to examine more deeply, actually in the part of whether students experience difficulties or in which components of student self directed learning need to be improved.

The description of the results of the four components of self directed learning is as follows:

3.1 Learning Motivation (LM)

Learning Motivation (LM) is the first and main component that must be owned by each individual. Motivation is seen as an attempt by someone to make certain choices, to be involved in action, to issue efforts and to survive in action [12]. Learning Motivation (LM) is seen as a core component in students and stimulation to motivate someone to learn [10]. The results obtained for the LM category areas in the following table:

Table 4. Table of setudent learning motivation

Statement number	Answers			
	SL	SR	KD	TP
1	12	63	51	3
2	80	47	2	0
3	24	80	25	0
4	52	53	23	1

From the table above, it can be seen that for statement 1 in the LM component only 12 people always behave like learning mathematics regardless of the value obtained. This means that only 9.3% of students consistently like mathematics, while 2.3% of students never like mathematics. For statement 2 there are 80 students who really hope to continue to improve their mathematical learning outcomes. This means that more than 50% of students have the motivation to continue learning mathematics. But the irony is that there are still students who do not care about the results of the mathematical values they get, as evidenced from the answers sometimes chosen, showing that there is no seriousness in learning mathematics. Furthermore, for statement 3, there were 62% of students who often tried not to give up learning mathematics despite facing some difficulties. This is a good sign, that the majority of students still want to try, this is also supported by the data that there are no students who choose "never". Finally, statement 4, data obtained that the comparison is almost the same between students who always and often want to ask for help from others to achieve goals when learning mathematics. This is positive because sometimes students are reluctant to ask or are ashamed to ask for help from their friends, for fear of being considered less intelligent.

3.2 Planning and Implementing (PI)

Planning and Implementing (PI) is guided as the ability to independently set learning goals, use appropriate strategies and learning resources so that learning objectives are achieved effectively [8]. The frequency for PI data is presented in the following table:

Table 5. Table of student planning and implementing

Statement number	SL	SR	KD	TP
5	15	62	50	2
6	6	47	76	0
7	6	33	86	4
8	27	54	48	0

In this PI component, there is a decrease in the number of activities that always do, at this stage students are more likely to choose often or even more, students choose to do it sometimes. This means that students are still weak at the stage of Planning and Implementing (PI), so there is a need for efforts to help students improve PI in mathematics. So it is not surprising if there are 4 or 3.1% of students who are not good at managing time to study mathematics. Practicing the ability of an individual learning plan can direct students to obtain better learning outcomes, and encourage students' Self-directed learning skills [13].

3.3 Self-Monitoring (SM)

Self-Monitoring (SM) is moment-by-moment awareness of the possibility of someone retaining the skills or knowledge to act in certain situations [14] or more generally SM is defined in the act of recording or evaluating the behavior of a self [15], or the ability to evaluate and supervise learning outcomes [10]. At this stage, students are given a related statement by knowing the weaknesses of self in learning, studying the results of learning, looking for relationships of knowledge and so forth. There are a number of results obtained in detail from 129 students for statements relating to SM, in no. 9-12, as follows:

Table 6. Table of setudent self-monitoring

Statement number	SL	SR	KD	TP
9	10	50	61	8
10	19	64	45	1
11	38	72	18	1
12	17	51	59	2

In this component, there is a very significant increase in the column never. That shown if in the PI component there are 6 answers for "never". But in this component, there was a 2 times increase compared to the previous 12 answers. This means that students still lack care and understand the importance of evaluating and monitoring the learning outcomes for themselves. We take the example in statement No. 9, which is that statement “I can connect new knowledge in mathematics with my own personal experience”. The number of students who choose Always with Never is only a difference of 2 students. This means that only a difference of 1.22% between the two. This indicates that there are 8 students who have never connected mathematics with personal experience so that later new concepts will be obtained based on previous students' knowledge or experience. The role of the teacher, in this case, is to help students by connecting material or new concepts to everyday life or problems that are closely related to student life. Based on research conducted by Schmitz stated that their SM procedures can be used to improve self-regulated learning in a natural learning environment [16]. So that SM is an important component that students need to have.

3.4 Interpersonal Communication (IC)

Interpersonal communication (IC) is the ability of students to interact with others in an effort to present or express their own knowledge [10]. Besides that, as an interpersonal communication competency refers to the individual's ability to manage interpersonal relationships in communication settings [17]. For this latest component, the statement consists of no. 13-15. The results obtained can be seen in the following table:

Table 7. Table of student interpersonal communication

Statement number	SL	SR	KD	TP
13	19	64	43	3
14	6	33	80	10
15	4	39	83	3

Based on the table above it can be seen that the majority of students choose answers sometimes. The choice of answers sometimes signifies that the lack of awareness of students' abilities is related to the interpretations made in mathematical learning. Even 83 students which mean 64.34% of students can sometimes communicate effectively in oral mathematical presentations. Even 10 students claimed not to be able to communicate effectively in oral mathematical presentations. So, the solution that can be done by a teacher to help students improve their abilities is to routinely conduct discussions and presentations in teaching concepts in mathematics learning.

Self directed learning can be increased by students, provided the students must understand that they will direct independent learning in their lives. These efforts must not always be helped by other people, but it really must be realized by the students themselves. But there are times when some students who have low self-directed need for help from others, because of that the teacher as a facilitator plays their role here. The teacher must be able to motivate students to grow these abilities in there own. In addition, teachers also need to pay attention to the appropriate learning methods in order to be able to improve students' interpersonal communication skills. Traditional learning methods will provide limited results [18].

4. CONCLUSION

Based on the results obtained above, it can be concluded that students' self-directed learning is 1.55% in the very high category, 35.65 in the High category, and 59.68% in the Medium category, and 3.10% in the low category. The results obtained from 129 students reflect that the average student is in the medium category. This requires improvement efforts that must be done by the teacher, or other related parties, including students. In addition, the in-depth review above explains from the four components of student learning independence, the fourth component namely Interpersonal communication (IC) is the lowest component of the ability of self-directed learning of the student.

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Blended Learning for Bilingual Math, Science and Technology Teachers' Professional Development in China

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ABSTRACT
In this paper, we analyzed the growth and development of international education programs in secondary schools in China, within which MSL (Mathematics, Science and Technology) education in a bilingual environment (mainly English and Mandarin) is an essential section. One of the barriers for their further expansion is the unbalanced regional distribution and the resulting shortage in qualified educators. Blended learning is adopted in teachers' professional development to optimize the allocation of resources with the help of online modules designed based on subjects and stages, followed by regular offline workshops.

CCS Concepts
• **Applied computing→Education→ E-learning**

Keywords
Blended Learning; Bilingual; Professional Development

1. INTRODUCTION
A more open China creates an increasing number of young Chinese studying abroad, the number of which went up to more than 600 thousand for 2017 with a year-to-year growth of 11.74%, according to the Ministry of Education of the People's Republic of China, which makes China the largest origin of international students for English-speaking countries [1]. In addition, the average age of students going abroad for study moves further down to 20.2 years old for 2017. Meanwhile, secondary school students within China also have opportunities to acquire international education in 821 domestic schools, where international education programs are adopted [2].

Imported with standard international curriculums including IB (International Baccalaureate), A-Level (General Certificate of Education Advanced Level), AP (Advanced Placement) and other secondary school curriculums from the US [3], UK [4], Australia and Canada, various subjects are offered among which MSL subjects including math, further math, physics, chemistry, biology, computer science and information technology dominate the most welcomed subjects for Chinese students. For example, Figure 1 illustrates the numbers of students in Mainland China taking different subjects in 2017-2018 International A-Level exams from Pearson Edexcel which is the largest A-Level provider. Within the total 47 subjects available from Edexcel, the top four popular subjects -- Math, Further Math, Physics, and Chemistry are all MSL subjects. The situation is quite similar in AP exam where the top 10 favorite subjects in China in 2018 are Calculus BC, Microeconomics, Macroeconomics, Statistics, Physics C Mechanics, Calculus AB, Physics 1, Chemistry, Psychology, and Computer Science A, according to the official information released on AP China Summit 2018. Among them, 7 out of 10 are MSL subjects (except Microeconomics, Macroeconomics, and Psychology). As a whole, the reason may fall into Chinese students' traditional preference on science and engineering majors in colleges and universities and the relatively high salary in the job market.

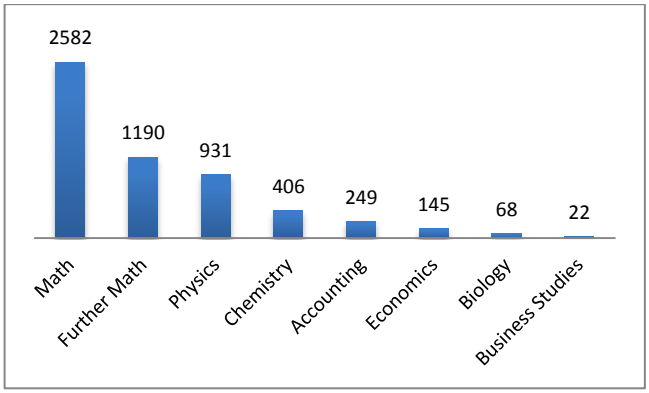

Figure 1. Numbers of students taking Edexcel International A Level exams of different subjects in Mainland China from October 2017 to June 2018.

Behind the prosperity of international MSL education in China there are also severe problems existing, which prevent the international MSL courses from an even faster development and spreading in China -- the unbalanced regional distribution as shown in Figure 2. Most schools adopted international education programs locate around the big cities such as Beijing and Shanghai or provinces along the east costal line such as Jiangsu, Zhejiang, Guangdong and Shandong. Developed areas receive more governmental support, attract more investment and have the most critical resources -- teachers, while on the contrary less developed inland areas do not keep up with the pace.

There are qualified English language teachers, and there are qualified MSL teachers in Chinese. However, there is a shortage of qualified bilingual MSL teachers. The reason is obvious that

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the talent market couldn't foresee the explosive expansion of international MSL education, and therefore responds with a delay.

A possible solution is to transform current English or MSL teachers to bilingual MSL teachers [5].

This task could be divided into two steps: assessment of current teachers and implementation of the transformation. The former is targeted to identify levels of teachers and figure out the potentials and inadequacies, while the latter is to design the corresponding professional development routes for teachers of each level and achieve the goals with the organic integration of both online and offline approaches, i.e., blended learning [6].

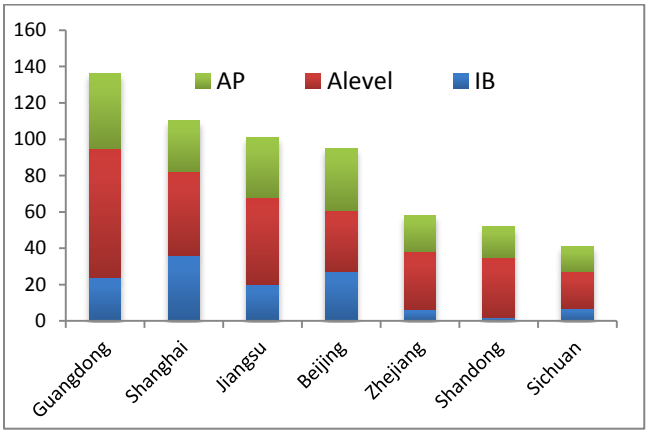

Figure 2. Distribution of international education programs in China in 2018.

2. ASSESSMENT OF TEACHERS

As shown in Table.1, teachers are evaluated on the basis of four dimensions: general education background, teaching experience, familiarity of teaching pedagogy and English language competence. First of all, a general threshold of becoming a bilingual MSL teacher is graduation from top universities either in China or oversea with a Bachelor's degree or above and majoring in MSL subjects or related. Afterwards, teachers are classified into three levels -- foundation, proficient and expert -- according to their teaching experience, scores of Standard English test such as TOEFL or IELTS, and qualification in teaching pedagogy such as in TKT CLIL (Teaching Knowledge Test, Content and Language Integrated Learning) granted from Cambridge Assessment.

Table 1. Benchmark for grading teachers

	FOUNDATION	PRIFICIENT	EXPERT
General Background	Top Universities from China OR Oversea Bachelor's degree and above		
Teaching Experience	0-2 years	2-6 years	> 6 years
TKT	none	TKT CLIL Band 3	TKT CLIL Band 4
Standard English Test	IELTS 6.5 TOEFL 90	IELTS 7 TOEFL 100	IELTS 7 TOEFL 100

Questionnaires with 65 teachers and interviews with 27 teachers and head teachers have been conducted in 9 secondary schools with international education programs in 9 different cities in China. Statistics are demonstrated in Figure 3 and 4.

Figure 3 shows a roughly equal distribution in teachers' working experience, with the starters (under 2 years) a little bit less and the 6-10 years a little bit more.

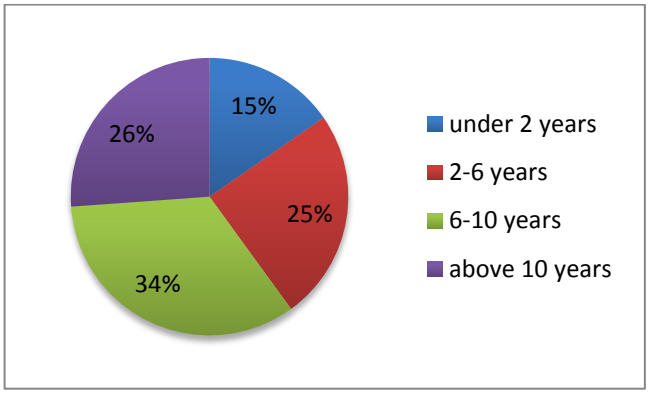

Figure 3. Distribution of teachers' working experience in the questionnaires.

Meanwhile, Figure 4 demonstrates the various responds of satisfaction with training from teachers according to their working experience. Under two years, the proportion of new teachers who are completely satisfied with training is higher (60%). With the increase of teaching age, this proportion continues to decline, while the proportion of new teachers who are partially satisfied with training is on the contrary, showing a continuous upward trend. The results show that the reason is that the starters are eager for training and hope that they can improve their teaching ability quickly through the training. However, because of their lack of experience, they will recognize all aspects of training. With the increase of teaching age and the improvement of teaching experience, teachers will be partially dissatisfied with the content or form of training when the types of follow-up training are repeated.

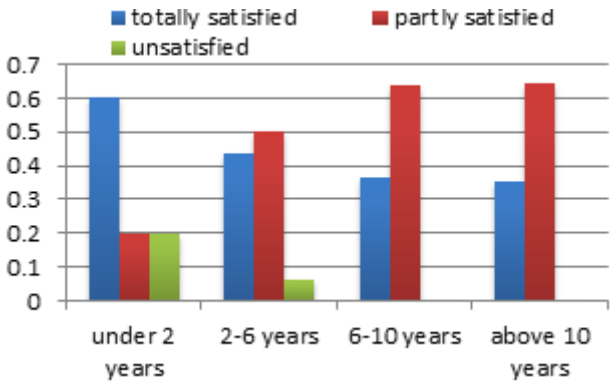

Figure 4. Levels of satisfaction based on teachers' working experience.

3. TEACHERS' TRAINING FRAMEWORK

Accordingly, analysis of teachers' self-assessment and demand, combined with the evaluation from external consultant, contributes to a suggested training framework in each stage (Foundation, Proficient, and Expert) as shown in Figure 5, considering the distinct requirement on English language competence, specialist subject knowledge, exam and curriculum familiarity, teaching pedagogy, and oversea training experience,

of each stage. A 3-point system is employed, where 3 is for highly required, 2 for recommended, and 1 for optional.

3.1 Foundation

Teachers' need at this stage is defined as 'purely theoretical input'. They have to improve their English especially speaking, to help them deliver their lessons in targeted language. Meanwhile they would need to reorganize the subject knowledge. Even though they may have received education related to the subject they are going to teach before, most of them have no experience delivering the contents in a class in English. And apart from that, the other thing they should get familiar with is the curriculum and exam, which includes the key points, the exams form and the assessment.

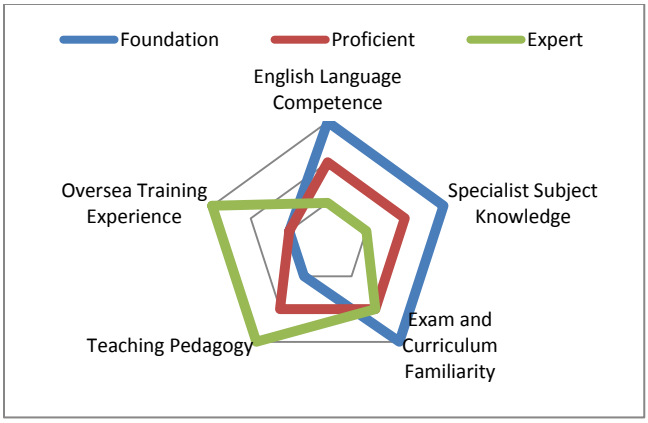

Figure 5. Training framework for different teachers.

3.2 Proficient

Upgraded into this stage, teachers' need is switched towards 'practical output'. How to attract students' interest, how to deconstruct complex concepts, how to deliver knowledge step by step, and how to help students build up their own learning autonomy, etc. become the main demands. Therefore, more attentions are paid on teaching pedagogy integrated with subject knowledge and exam and curriculum familiarity.

3.3 Expert

Finally, growing up to the level of top bilingual teachers, expert teachers focus more on being able to impart an international vision to their students; therefore, 'immersed experience' is put on the agenda at this stage in the form of oversea training or exchange experience in other schools and/or organizations where the programs are originated.

4. BLENDED LEARNING COMMUNITY

Five corresponding training modules are developed either online or offline as shown in Figure 6. They are configured on the basis that more general and theoretical trainings go for online platform, while more specific and practical trainings go for offline workshops [7].

Furthermore, in this blended learning community, teachers not only perform as receivers but also as contributors and maintainers at the same time, and are thus referred to as 'transceivers'. Members from the Proficient group are responsible for the construction and development followed by verifications from members from the Expert group. Foundation group take the training and bring back feedback afterwards. Therefore, a close loop is established to promote the self-optimization and update of the system.

4.1 Module 1

Module 1 is for English language training, which is provided purely online. Teachers from all three groups have access to the public English learning resources such as IELTS and TOEFL training courses, where they can organize their improvement plan according to their own levels of language. This module is most important for teachers from the Foundation group, who are required not only to study online but also to take the exams. As a result, their language level is traceable which would be one of the prerequisite for upgrading. Meanwhile, teachers from the Proficient and Expert groups are recommended to study SAT and ACT, since they can get to know their students' level of understanding in MSL subjects through the math and science test part, which would help build a student-oriented teaching strategy later on.

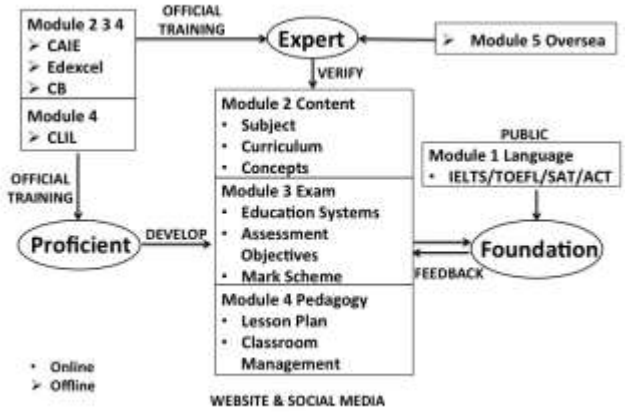

Figure 6. Blended learning community.

4.2 Module 2-4

4.2.1 Platform

Module 2, 3 and 4 are for specialist subject knowledge, exam and curriculum familiarity, and teaching pedagogy, respectively, which are mainly online via two platforms: a self-developed website and one of the largest Social Media in China -- Wechat. The contents delivered are the same, while the formats are different, thus covering both the computer and smartphone learners. Figure 7 demonstrates an example of Wechat interface for A-level Math from Pearson Edexcel, which is accessed by easily scanning the QR code. Learners can choose the specific subjects they would like to do and start the video. Their progress is recorded in their Wechat account, and is therefore possible to pause and restart at any time. Rating and favorites as well as text comments (not shown in the figure) are also available for uses uploading their feedback to the developers.

4.2.2 Recorded Broadcast

Most of the videos on the platform are recorded broadcast, which would require a pretty long period of preparation and development (at least one year). As illustrated in Figure 8, the first development round started with demand investigation from the Foundation group of different cities, followed by structure analysis and task allocation from the Expert group and finished by accomplishment of the detailed script from the Proficient group. The second round is based on the previous achievement, which is verified first by the Expert group and then by authentic experts. Feedbacks from them are passed on to the Proficient group and

adjustment and improvement are given accordingly. This round could undergo for several turns until both sides reach an agreement. The third round is focused on the record of the video strictly consistent with the scripts. Sample video would be tested on the Foundation group, who are expected to supply a client side feedback. As before, modifications and tests would take several turns until finally the formal version is open to public.

Figure 7. Online training example with Wechat interface.

4.2.3 Live Broadcast

There is also live broadcast sometimes. For example, A-Level exam providers CAIE (Cambridge Assessment International Education) and Pearson Edexcel and AP exam provider CB (College Board) supply offline trainings time to time. And the Proficient or Expert group would have the opportunity to participate in. Afterwards, a live broadcast will be held on Wechat group including all of the teachers where the participants of offline trainings share what they have learned and the audiences are also welcome to post their questions. Up to date, there are over 150 members over 25 cities in the Wechat group.

In brief, the recorded broadcast guarantees a systematic training while the live broadcast performs as a complement.

4.3 Module 5

Module 5 is oversea training, which is purely offline. The aim is to provide an immersed environment for Expert group to extend their academic background, to catch up with the latest progress of advanced science and technology and to cultivate an internal understanding of international vision.

Nowadays, two types of oversea trainings are available. One is in the form of 3-5weeks short courses in universities and the other is in the form of teaching observation in schools. The locations are mainly in the places where most of the students go for further study such as the US and UK but not limited. More cooperative partners are on exploring.

In principle only Expert group are welcome for application due to their relatively high abilities. Potential candidates are required to submit supporting materials such as evidence of their language proficiency, study plan, research proposal for pedagogy, etc. which will be evaluated comprehensively. While after the training, the trainees are also responsible to share their experience and comprehension in various formats, including but not limited to self-reflection forms, essays, etc..

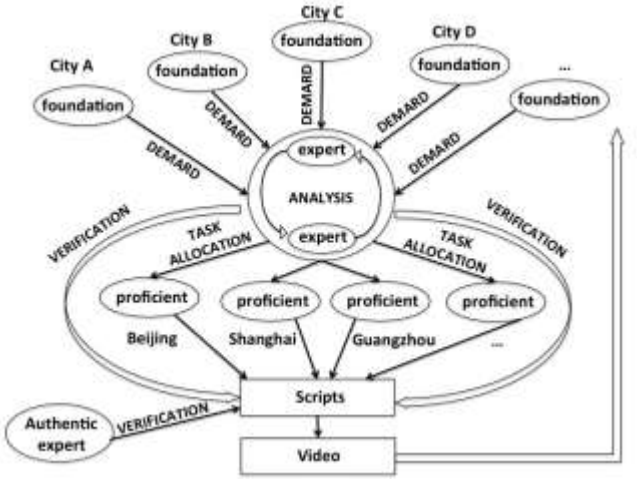

Figure 8. Flow chart of R&D (research and development) for recorded broadcast with a close loop.

4.4 Offline Workshop

There are three different levels of offline workshops operating at the moment: entrance, growth and R&D. All the three workshops are organized and promoted by the members from the Expert group, of which normally 1-2 persons are responsible for each subject. Concerned with the regional radiation, the workshops are not only located in the headquarter in Beijing, but also in Shanghai for the eastern part, Wuhan for the middle part, Guangzhou for the southern part and Xi'an for the western part as shown in Figure 9, which switch in turns generally every half-year. Each workshop lasts for similar time around 3-5 days full but it varies in objectives, contents, formats and outcomes as shown in Table 2.

4.4.1 Entrance Workshop

The entrance workshop is for Foundation group with two targets, one of which is to guide the new comers how to use the online system efficiently and the other is to provide an on-site demonstration of how to manage a class. Workshops at this level are mainly in the forms of training where the trainees receive a large amount of inputted information that they should digest later on. Furthermore, they have to hand in the weekly report stating their experience and application in their own class after the workshop. Therefore, how much they have absorbed from the online modules is traceable until they upgrade to the next stage.

4.4.2 Growth Workshop

The growth workshop is for Proficient group concentrating on the teaching pedagogy. Meanwhile, this level of workshop is in the form of team project. Each team has one leader from Expert group plus 5 members from Proficient group in the same MSL subject. The leader would propose a topic for example 'Circular Motion' in physics, around which the 5 members have to discuss how to plan a lesson, how to manipulate the details in a logical and concise manner, how to search and apply assistant tools, how to deliver the knowledge and how to design interactive class. The members would have 1-2 days to finish while the leader observes

and instructs during the whole process. Afterwards, a representative of each team is put forward to demonstrate the outcome on the spot in the form of competition. Teams of each MSL subject are included and self-reflection as well as cross evaluation is adopted where all the members of Proficient group are able to experience a collaborative learning.

Figure 9. Distribution of workshop in recent three years.

4.4.3 R&D Meeting

The R&D meeting is the regular meeting for the purpose of online training contents research and development. It aims at optimizing and updating the current system, which starts with reflections from feedback of previously conducted training programs, proceeds to analysis of the up-to-date resources and information, then comes up to the final of modification.

Table 2. Three levels of workshop

	ENTRANCE	GROWTH	R&D
Trainer	Expert	Expert	Expert and Proficient
Trainee	Foundation	Proficient	
Content	1. instruction of online system 2. on-site demo of teaching method	Teaching methodology	Online system development
Form	Training	Group work	Discussion
Achievement	Traceable improvement	Collaborative learning	Optimize and Update

5. CONCLUSION

International education programs in secondary schools in China will sustain the increasing growth, presenting an inevitable pressure on talent market of bilingual MSL teachers. Efficient training program is urgently required for satisfying the demand covering the time and space issues. Blended learning therefore becomes the optimal choice where online instructional courses and offline experiential and cooperative learning are complementary. Both website and social media Wechat were utilized for construction of the online community and regular face-to-face workshops were setup in regional central cities with certain radiant ability. It is expected that in the future more teachers who would like to participate in bilingual MSL teaching have the instant access to a complete, functional and customized professional development.

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Online Inverse Covariance Matrix: In Application to Predictive Distribution of Gaussian Process

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ABSTRACT
Some statistical analysis needs an inverse covariance matrix computing. A Gaussian process is a non-parametric method in statistical analysis that has been applied to some research. The Gaussian process needs an inverse covariance matrix computing by given data. Inverse matrix on Gaussian process becomes interesting problems in Gaussian process when it is applied in real time and have big number data. Increasing data number and covariance matrix size need an effective computing algorithm. Some online Gaussian process is developed to solve those real-time cases and increasing of covariance matrix size. Here, we discuss how online Gaussian process is built from an online algorithm of inverse covariance matrix. We do simulation online inverse covariance matrix for efficient time-computing of Gaussian process predictive distribution. We compare performance of online inverse covariance matrix and offline inverse covariance matrix to predictive distribution of Gaussian process. The result shows that time-computing online inverse covariance matrices are faster than offline. Meanwhile, the online inversion to Gaussian process shows that predictive Gaussian processes have the same root mean square error (RMSE) compare to offline inversion. It means that inversion by online affects time-computing, but still the predictive distribution of Gaussian process is preserved.

CCS Concepts
• Mathematics of computing→Probability and statistics→Nonparametrics statistics

Keywords
Gaussian process, online Inverse covariance matrix, predictive distribution.

1. INTRODUCTION
The covariance matrix of multivariate analysis is an interesting problem, especially on its Inverse problem. Inverse covariance matrix problems are used on some subjects as on stochastic Gaussian process [1], economic-price analysis [2], finance on portfolio analysis [3][4], and engineering [5]. Some latest papers about an inverse matrix are inverse iterative methods by Hyper-power iterative method [6], a Monte Carlo approach [7], and sequential inverse approximation [8]. Meanwhile, some articles about inverse covariance matrix are approximating inverse symmetric positive definite matrix by boundary [9], an inverse of Gram matrix and nonnegativity [10], and fast inverse covariance matrix based using Hermitian matrix [11]. In this paper, the purpose of an online inverse covariance matrix is getting real-time computing of inversion that can be applied to an online algorithm. The iterative idea is finding inverse from its sub-matrix inverse which is obtained by the last iteration for efficiency real-time computing.

Gaussian processes as non-parametric regression have been applied on transmission spectroscopy modelling [12], tsunami modelling [13], coastal groundwater management [14], and gas reservoir analysis [15]. Mostly, those applications should be built by online algorithms for an efficient time-computation. The Bayesian inference of a Gaussian process needs a prior distribution before observing new data [16]. It is a predictive distribution. It predicts the mean and variance of new coming data.

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2. PREDICTIVE DISTRIBUTION OF GAUSSIAN PROCESS
Gaussian process is defined as a collection of random variables, which any finite number of random variables have a multivariate joint Gaussian distribution. Mathematically, stochastics process $\{Y_t\}_{t\geq 0}$ is a Gaussian if for any $t_1, t_2, \dots, t_n \in \mathbb{R}$, the distribution of the random vector $(Y_{t_1}, Y_{t_2}, \dots, Y_{t_n}) \in \mathbb{R}^n$ is a Gaussian distribution in $\mathbb{R}^n$. Let given sequence pair of data observations $(x,y)_{\boldsymbol{t_1}:\boldsymbol{t_n}} = \left((x_{\boldsymbol{t_1}}, y_{\boldsymbol{t_1}}), (x_{t_2}, y_{\boldsymbol{t_2}}), \dots, (x_{t_n}, y_{\boldsymbol{t_n}})\right)$, where $y_{\boldsymbol{t_1}:\boldsymbol{t_n}}=(y_{t_1}, y_{t_2}, \dots, y_{t_n})^T$ are data responds (output) of data input $x_{\boldsymbol{t_1}:\boldsymbol{t_n}}=(x_{t_1}, x_{t_2}, \dots, x_{t_n})^T$ respectively. Moreover, Gaussian process y_x can be represented as:

$$y_x = f(x) + \varepsilon_x, \quad ; \varepsilon_x \sim N(0, \sigma^2)$$

Here, ε_x represents the noise and $f(x)$ represents the function that becomes model of multivariate normal distribution with mean function $\mu(x)$ and covariance function $K(x)$.

Let that we already have a predictive distribution of Gaussian process given $y_{\boldsymbol{t_1}:\boldsymbol{t_n}}=(y_{t_1}, y_{t_2}, \dots, y_{t_n})^T$ with matrix $\boldsymbol{K_{t_n}}$. Every element of matrix is covariance of every pair element on $(y_{t_1}, y_{t_2}, \dots, y_{t_n})$. Covariances of every pair are built from covariance function. Covariance function is kernel function $k(x, x')$ from input pairs of $(x_{t_1}, x_{t_2}, \dots, x_{t_n})$. There are some of kernel function that are used as covariance function: exponential, Squared exponential, $\gamma-$ exponential, Matern class, rational

quadratic, piecewise polynomial, Periodic, linear function and etc [1].

Let the new data pair $(x_{t_{n+1}} y_{t_{n+1}})$ comes, then predictive distribution of $y_{t_{n+1}}$ given $y_{\boldsymbol{t_1:t_n}} = (y_{t_1}, y_{t_2}, \dots, y_{t_n})^T$, is Gaussian distribution with mean $m_{t_{n+1}}$ and variance $v_{t_{n+1}}$

$$p(y_{t_{n+1}} | y_{t_1}, y_{t_2}, \dots, y_{t_n}, \theta_m) = N(m_{t_{n+1}}, v_{t_{n+1}}) \qquad (1)$$

Where:

$m_{t_{n+1}} = \boldsymbol{k_*^T}(\boldsymbol{K_{t_n}} + \sigma_n^2 I)^{-1} y_{\boldsymbol{t_1:t_n}}$

$\boldsymbol{y_{t_1:t_n}} = (y_{t_1}, y_{t_2}, \dots, y_{t_n})$

$\boldsymbol{k_*} = k(y_{t_1:t_n}, y_{t_{n+1}})$; $\boldsymbol{K_{t_n}} = k(y_{t_1:t_n}, y_{t_1:t_n})$

$v_{t_{n+1}} = k(y_{t_n}, y_{t_n}) - k_*^T (K + \sigma_n^2 I)^{-1} k_*$.

3. ONLINE INVERSE COVARIANCE MATRIX

3.1 Covariance Matrix

Let $\boldsymbol{K_{t_n}}$ is covariance matrix of Gaussian process and inverse covariance matrix is $\boldsymbol{K_{t_n}^{-1}}$. Covariance of output data y_{t_i} and y_{t_j} is calculated by covariance function of input x_{t_i} and x_{t_j}, $k\left(x_{t_i}, x_{t_j}\right)$. Let denote $\left(x_{t_i}, x_{t_j}\right) = \langle x_{t_i}, x_{t_j} \rangle$. Let $\boldsymbol{K_{t_{n-1}}}$ and $\boldsymbol{K_{t_n}}$ are covariance matrices, below

$$\boldsymbol{K_{t_{n-1}}} = \begin{bmatrix} \langle x_{t_1}, x_{t_1} \rangle & \langle x_{t_1}, x_{t_2} \rangle & \dots & \langle x_{t_1}, x_{t_{n-1}} \rangle \\ \langle x_{t_2}, x_{t_1} \rangle & \langle x_{t_2}, x_{t_2} \rangle & \dots & \langle x_{t_2}, x_{t_{n-1}} \rangle \\ \dots & \dots & \dots & \dots \\ \langle x_{t_{n-1}}, x_{t_1} \rangle & \langle x_{t_{n-1}}, x_{t_2} \rangle & \dots & \langle x_{t_{n-1}}, x_{t_{n-1}} \rangle \end{bmatrix}$$

$$\boldsymbol{K_{t_n}} = \begin{bmatrix} \langle x_{t_1}, x_{t_1} \rangle & \langle x_{t_1}, x_{t_2} \rangle & \dots & \langle x_{t_1}, x_{t_{n-1}} \rangle & \langle x_{t_1}, x_{t_n} \rangle \\ \langle x_{t_2}, x_{t_1} \rangle & \langle x_{t_2}, x_{t_2} \rangle & & & \langle x_{t_2}, x_{t_n} \rangle \\ \dots & \dots & & \dots & \dots \\ \langle x_{t_{n-1}}, x_{t_1} \rangle & \langle x_{t_{n-1}}, x_{t_2} \rangle & \dots & \langle x_{t_{n-1}}, x_{t_{n-1}} \rangle & \langle x_{t_{n-1}}, x_{t_n} \rangle \\ \langle x_{t_n}, x_{t_1} \rangle & \langle x_{t_n}, x_{t_2} \rangle & \dots & \langle x_{t_n}, x_{t_{n-1}} \rangle & \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix}$$

Clearly, that

$$\boldsymbol{K_{t_n}} = \begin{bmatrix} \boldsymbol{K_{t_{n-1}}} & \boldsymbol{k_*} \\ \boldsymbol{k_*^T} & \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix}$$

Where $\boldsymbol{k_*} = \begin{bmatrix} \langle x_{t_1}, x_{t_n} \rangle \\ \dots \\ \langle x_{t_{n-1}}, x_{t_n} \rangle \end{bmatrix}$.

3.2 Online Inverse Covariance Matrix

Let assume that inverse covariance matrix is exist. Let $\boldsymbol{K_{t_n}}$ is notation of covariance matrix and inverse covariance matrix is $\boldsymbol{K_{t_n}^{-1}}$. Covariance of output data y_{t_i} and y_{t_j} is calculated by covariance function of input x_{t_i} and x_{t_j}. Let denote $\left(x_{t_n}, x_{t_n}\right) = \langle x_{t_n}, x_{t_n} \rangle$. The idea of online covariance matrix is to build computation of current inverse covariance $\left(\boldsymbol{K_{t_n}^{-1}}\right)$ from $\left(\boldsymbol{K_{t_{n-1}}^{-1}}\right)$, the inverse covariance of sub matrix.

***Lemma* 1.**

Let $\boldsymbol{K_{t_n}} \in \mathbb{R}^{(n)\times(n)}$ is covariance matrix, then:

$$\boldsymbol{K_{t_n}^{-1}} = \begin{bmatrix} \boldsymbol{A} & \boldsymbol{b} \\ \boldsymbol{c} & d \end{bmatrix}$$

$\boldsymbol{A} \in \mathbb{R}^{(n-1)\times(n-1)}$; $\boldsymbol{b} \in \mathbb{R}^{(n-1)x1}$; $\boldsymbol{c} \in \mathbb{R}^{1\times(n-1)}$; $d \in \mathbb{R}$

Where:

$$\boldsymbol{A} = \boldsymbol{K_{t_{n-1}}^{-1}} + \frac{\boldsymbol{K_{t_{n-1}}^{-1} k_* k_*^T K_{t_{n-1}}^{-1}}}{\langle x_{t_n}, x_{t_n} \rangle - \boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*}}$$

$$\boldsymbol{b} = -\frac{\boldsymbol{A k_*}}{\langle x_{t_n}, x_{t_n} \rangle}$$

$$\boldsymbol{c} = -\frac{\boldsymbol{k_*^T K_{t_{n-1}}^{-1}}}{\langle x_{t_n}, x_{t_n} \rangle - \left(\boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*}\right)}$$

$$\boldsymbol{d} = \frac{1}{\langle x_{t_n}, x_{t_n} \rangle - \left(\boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*}\right)}$$

Proof:

Let $\boldsymbol{K_{t_n}^{-1}} = \begin{bmatrix} \boldsymbol{A} & \boldsymbol{b} \\ \boldsymbol{c} & d \end{bmatrix}$,

$\boldsymbol{K_{t_n}^{-1} K_{t_n}} = \boldsymbol{K_{t_n} K_{t_n}^{-1}} = \boldsymbol{I_{n\times n}}$

Take left multiplication $\boldsymbol{K_{t_n}^{-1}}$,

$\boldsymbol{K_{t_n}^{-1} K_{t_n}} = \boldsymbol{I_{n\times n}}$

$$\begin{bmatrix} \boldsymbol{A} & \boldsymbol{b} \\ \boldsymbol{c} & d \end{bmatrix} \begin{bmatrix} \boldsymbol{K_{t_{n-1}}} & \boldsymbol{k_*} \\ \boldsymbol{k_*^T} & \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix} = \begin{bmatrix} \boldsymbol{I_{(n-1)\times(n-1)}} & \boldsymbol{O_{(n-1)\times 1}} \\ \boldsymbol{O_{1\times(n-1)}} & 1 \end{bmatrix}$$

$$\begin{bmatrix} [\boldsymbol{A} & \boldsymbol{b}] \begin{bmatrix} \boldsymbol{K_{t_{n-1}}} \\ \boldsymbol{k_*^T} \end{bmatrix} & [\boldsymbol{A} & \boldsymbol{b}] \begin{bmatrix} \boldsymbol{k_*} \\ \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix} \\ [\boldsymbol{c} & d] \begin{bmatrix} \boldsymbol{K_{t_{n-1}}} \\ \boldsymbol{k_*^T} \end{bmatrix} & [\boldsymbol{c} & d] \begin{bmatrix} \boldsymbol{k_*} \\ \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix} \end{bmatrix} = \begin{bmatrix} \boldsymbol{I_{(n-1)\times(n-1)}} & \boldsymbol{O_{(n-1)\times 1}} \\ \boldsymbol{O_{1\times(n-1)}} & 1 \end{bmatrix}$$

Here how to get $\boldsymbol{A}$, vector $\boldsymbol{b}$, row vector $\boldsymbol{c}$ and d:

1) $[\boldsymbol{c} \quad d] \begin{bmatrix} \boldsymbol{k_*} \\ \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix} = 1$;

$$\boldsymbol{c k_*} + d\langle x_{t_n}, x_{t_n} \rangle = 1$$

2) $[\boldsymbol{c} \quad d] \begin{bmatrix} \boldsymbol{K_{t_{n-1}}} \\ \boldsymbol{k_*^T} \end{bmatrix} = \boldsymbol{O_{1\times(n-1)}}$

$$\boldsymbol{c K_{t_{n-1}}} + d\boldsymbol{k_*^T} = \boldsymbol{O_{1\times(n-1)}}$$

$$\boldsymbol{c K_{t_{n-1}}} = -d\,\boldsymbol{k_*^T}$$

$$\boldsymbol{c K_{t_{n-1}} K_{t_{n-1}}^{-1}} = -d\,\boldsymbol{k_*^T K_{t_{n-1}}^{-1}}$$

$$\boldsymbol{c\,I} = -d\,\boldsymbol{k_*^T K_{t_{n-1}}^{-1}}$$

$$\boldsymbol{c} = -d\,\boldsymbol{k_*^T K_{t_{n-1}}^{-1}}$$

Substitute result on 2): $\boldsymbol{c} = -d\,\boldsymbol{k_*^T K_{t_{n-1}}^{-1}}$ to result on 1), then

$$\boldsymbol{c k_*} + d\langle x_{t_n}, x_{t_n} \rangle = 1$$

$$-d\,\boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*} + d\langle x_{t_n}, x_{t_n} \rangle = 1$$

$$d\left(\langle x_{t_n}, x_{t_n} \rangle - \left(\boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*}\right)\right) = 1$$

$$d = \frac{1}{\langle x_{t_n}, x_{t_n} \rangle - \left(\boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*}\right)} \qquad \blacksquare$$

Then we get,

$$\boldsymbol{c} = -\frac{\boldsymbol{k_*^T K_{t_{n-1}}^{-1}}}{\langle x_{t_n}, x_{t_n} \rangle - \left(\boldsymbol{k_*^T K_{t_{n-1}}^{-1} k_*}\right)} \qquad \blacksquare$$

3) $[\boldsymbol{A} \quad \boldsymbol{b}] \begin{bmatrix} \boldsymbol{k_*} \\ \langle x_{t_n}, x_{t_n} \rangle \end{bmatrix} = \boldsymbol{O_{(n-1)\times 1}}$

$$\boldsymbol{A k_*} + \langle x_{t_n}, x_{t_n} \rangle \boldsymbol{b} = \boldsymbol{O_{(n-1)\times 1}}\ ;\ \boldsymbol{A k_*} \in \mathbb{R}^{(n-1)\times 1}$$

$$\langle x_{t_n}, x_{t_n} \rangle \boldsymbol{b} = -\boldsymbol{A k_*}$$

$$\boldsymbol{b} = -\frac{\boldsymbol{A}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle} \quad \blacksquare$$

4) $\begin{bmatrix}\boldsymbol{A} & \boldsymbol{b}\end{bmatrix}\begin{bmatrix}\boldsymbol{K}_{t_{n-1}} \\ \boldsymbol{k}_*^{\,T}\end{bmatrix} = \boldsymbol{I}_{(n-1)\times(n-1)}$

$$\boldsymbol{A}\boldsymbol{K}_{t_{n-1}} + \boldsymbol{b}\boldsymbol{k}_*^{\,T} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

Substitute result $= -\frac{\boldsymbol{A}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle}$, then

$$\boldsymbol{A}\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{A}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle}\boldsymbol{k}_*^{\,T} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

$$\boldsymbol{A}\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{A}\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

$$\boldsymbol{A}\left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right) = \boldsymbol{I}_{(n-1)\times(n-1)}$$

$$\boldsymbol{A} = \left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right)^{-1}$$

Based on equation 14 on Henderson paper [17] that

$$(K + uv^T)^{-1} = K^{-1} - \frac{K^{-1}uv\prime K^{-1}}{1+v\prime K^{-1}u} \quad (2)$$

Then

$$A = \left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right)^{-1} = \boldsymbol{K}_{t_{n-1}}^{-1} - \frac{\boldsymbol{K}_{t_{n-1}}^{-1}\left(-\frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right)\boldsymbol{K}_{t_{n-1}}^{-1}}{1-\frac{\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle}}$$

$$= \boldsymbol{K}_{t_{n-1}}^{-1} + \frac{\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}^{-1}}{\langle x_{t_n}, x_{t_n}\rangle - \boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*} \quad \blacksquare$$

***Lemma* 2.**

Let $\boldsymbol{K}_{t_n} \in \mathbb{R}^{(n)\times(n)}$ is covariance matrix, then:

$$\left(\boldsymbol{K}_{t_n}\right)^{-1} = \begin{bmatrix}\boldsymbol{A} & \boldsymbol{b} \\ \boldsymbol{c} & d\end{bmatrix}$$

$\boldsymbol{A} \in \mathbb{R}^{(n-1)\times(n-1)}; \boldsymbol{b} \in \mathbb{R}^{(n-1)x1}$; $\boldsymbol{c} \in \mathbb{R}^{1\times(n-1)}; d \in \mathbb{R}$

Where:

$$\boldsymbol{A} = \boldsymbol{K}_{t_{n-1}}^{-1} + \frac{\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}^{-1}}{\langle x_{t_n}, x_{t_n}\rangle - \boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*}$$

$$\boldsymbol{b} = -\frac{\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle - \left(\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}{}^{-1}\boldsymbol{k}_*\right)}$$

$$\boldsymbol{c} = -\frac{\boldsymbol{k}_*^{\,T}\boldsymbol{A}}{\langle x_{t_n}, x_{t_n}\rangle}$$

$$d = \frac{1}{\langle x_{t_n}, x_{t_n}\rangle - \left(\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}{}^{-1}\boldsymbol{k}_*\right)}$$

Proof:

Take right multiplication $\boldsymbol{K}_{t_n}^{-1}$,

$$\boldsymbol{K}_{t_n}\boldsymbol{K}_{t_n}^{-1} = \boldsymbol{I}_{n\times n}$$

$$\begin{bmatrix}\boldsymbol{K}_{t_{n-1}} & \boldsymbol{k}_* \\ \boldsymbol{k}_*^{\,T} & \langle x_{t_n}, x_{t_n}\rangle\end{bmatrix}\begin{bmatrix}\boldsymbol{A} & \boldsymbol{b} \\ \boldsymbol{c} & d\end{bmatrix} = \begin{bmatrix}\boldsymbol{I}_{(n-1)\times(n-1)} & \boldsymbol{O}_{(n-1)\times 1} \\ \boldsymbol{O}_{1\times(n-1)} & 1\end{bmatrix}$$

$$\begin{bmatrix}[\boldsymbol{K}_{t_{n-1}} \quad \boldsymbol{k}_*]\begin{bmatrix}\boldsymbol{A} \\ \boldsymbol{c}\end{bmatrix} & [\boldsymbol{K}_{t_{n-1}} \quad \boldsymbol{k}_*]\begin{bmatrix}\boldsymbol{b} \\ d\end{bmatrix} \\ [\boldsymbol{k}_*^{\,T} \quad \langle x_{t_n}, x_{t_n}\rangle]\begin{bmatrix}\boldsymbol{A} \\ \boldsymbol{c}\end{bmatrix} & [\boldsymbol{k}_*^{\,T} \quad \langle x_{t_n}, x_{t_n}\rangle]\begin{bmatrix}\boldsymbol{b} \\ d\end{bmatrix}\end{bmatrix} = \begin{bmatrix}\boldsymbol{I}_{(n-1)\times(n-1)} & \boldsymbol{O}_{(n-1)\times 1} \\ \boldsymbol{O}_{1\times(n-1)} & 1\end{bmatrix}$$

Here how to get $\boldsymbol{A}$, coloum vector $\boldsymbol{b}$, row vector $\boldsymbol{c}$ and skalar d:

1) $[\boldsymbol{k}_*^{\,T} \quad \langle x_{t_n}, x_{t_n}\rangle]\begin{bmatrix}\boldsymbol{b} \\ d\end{bmatrix}$=1

$$\boldsymbol{k}_*^{\,T}\boldsymbol{b} + d\langle x_{t_n}, x_{t_n}\rangle = 1$$

2) $[\boldsymbol{K}_{t_{n-1}} \quad \boldsymbol{k}_*]\begin{bmatrix}\boldsymbol{b} \\ d\end{bmatrix} = \boldsymbol{O}_{(n-1)\times 1}$

$$\boldsymbol{K}_{t_{n-1}}\boldsymbol{b} + d\boldsymbol{k}_* = \boldsymbol{O}_{(n-1)\times 1}$$

$$\boldsymbol{K}_{t_{n-1}}\boldsymbol{b} = -d\boldsymbol{k}_*$$

$$\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{K}_{t_{n-1}}\boldsymbol{b} = -d\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*$$

$$\mathbf{I}\,\boldsymbol{b} = -d\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*$$

$$\boldsymbol{b} = -d\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*$$

Substitute result on 2): $\boldsymbol{b} = -d\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*$ to result on 1), then

$$-d\boldsymbol{k}_*^{\,T}\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_* + d\langle x_{t_n}, x_{t_n}\rangle = 1$$

$$-d\,\boldsymbol{k}_*^{\,T}\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_* + d\langle x_{t_n}, x_{t_n}\rangle = 1$$

$$d\left(\langle x_{t_n}, x_{t_n}\rangle - \left(\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}{}^{-1}\boldsymbol{k}_*\right)\right) = 1$$

$$d = \frac{1}{\langle x_{t_n}, x_{t_n}\rangle - \left(\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}{}^{-1}\boldsymbol{k}_*\right)} \quad \blacksquare$$

Then we get,

$$\boldsymbol{b} = -\frac{\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle - \left(\boldsymbol{k}_*^{\,T}\boldsymbol{K}_{t_{n-1}}{}^{-1}\boldsymbol{k}_*\right)} \quad \blacksquare$$

3) $[\boldsymbol{k}_*^{\,T} \quad \langle x_{t_n}, x_{t_n}\rangle]\begin{bmatrix}\boldsymbol{A} \\ \boldsymbol{c}\end{bmatrix} = \boldsymbol{O}_{(n-1)\times 1}$

$$\boldsymbol{k}_*^{\,T}\boldsymbol{A} + \langle x_{t_n}, x_{t_n}\rangle\boldsymbol{c} = \boldsymbol{O}_{(n-1)\times 1}\,;\ \boldsymbol{k}_*^{\,T}\boldsymbol{A} \in \mathbb{R}^{(n-1)\times 1}$$

$$\langle x_{t_n}, x_{t_n}\rangle\boldsymbol{c} = -\boldsymbol{k}_*^{\,T}$$

$$\boldsymbol{c} = -\frac{\boldsymbol{k}_*^{\,T}\boldsymbol{A}}{\langle x_{t_n}, x_{t_n}\rangle} \quad \blacksquare$$

4) $[\boldsymbol{K}_{t_{n-1}} \quad \boldsymbol{k}_*]\begin{bmatrix}\boldsymbol{A} \\ \boldsymbol{c}\end{bmatrix} = \boldsymbol{I}_{(n-1)\times(n-1)}$

$$\boldsymbol{K}_{t_{n-1}}\boldsymbol{A} + \boldsymbol{k}_*\boldsymbol{c} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

Substitute result on 3):$\boldsymbol{c} = -\frac{\boldsymbol{k}_*^{\,T}\boldsymbol{A}}{\langle x_{t_n}, x_{t_n}\rangle}$, then

$$\boldsymbol{K}_{t_{n-1}}\boldsymbol{A} - \boldsymbol{k}_*\frac{\boldsymbol{k}_*^{\,T}\boldsymbol{A}}{\langle x_{t_n}, x_{t_n}\rangle} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

$$\left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right)\boldsymbol{A} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

$$\left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right)\boldsymbol{A} = \boldsymbol{I}_{(n-1)\times(n-1)}$$

$$\boldsymbol{A} = \left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}}{\langle x_{t_n}, x_{t_n}\rangle}\right)^{-1}$$

$$A = \left(\boldsymbol{K}_{t_{n-1}}\right)^{-1} + \left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\boldsymbol{k}_*\boldsymbol{k}_*^{\,T}\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}\alpha$$

Based on equation 14 on Henderson paper [17] that

$$(K + uv^T)^{-1} = K^{-1} - \frac{K^{-1}uv^TK^{-1}}{1+v^TK^{-1}u} \quad (2)$$

Then

$$A = \left(\boldsymbol{K}_{t_{n-1}} - \frac{\boldsymbol{k}_*\boldsymbol{k}_*^T}{\langle x_{t_n}, x_{t_n}\rangle} \right)^{-1} = \boldsymbol{K}_{t_{n-1}}^{-1} - \frac{\boldsymbol{K}_{t_{n-1}}^{-1}\left(-\frac{\boldsymbol{k}_*\boldsymbol{k}_*^T}{\langle x_{t_n}, x_{t_n}\rangle}\right)\boldsymbol{K}_{t_{n-1}}^{-1}}{1-\frac{\boldsymbol{k}_*^T\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*}{\langle x_{t_n}, x_{t_n}\rangle}}$$

$$= \boldsymbol{K}_{t_{n-1}}^{-1} + \frac{\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*\boldsymbol{k}_*^T\boldsymbol{K}_{t_{n-1}}^{-1}}{\langle x_{t_n}, x_{t_n}\rangle - \boldsymbol{k}_*^T\boldsymbol{K}_{t_{n-1}}^{-1}\boldsymbol{k}_*} \quad \blacksquare$$

From Lemma 1) and Lemma 2), we get Corollary 1, as follow

Corollary 1.

Let $\boldsymbol{K}_{t_n} \in \mathbb{R}^{(n)\times(n)}$ is covariance matrix then:

$$\left(\boldsymbol{K}_{t_n}\right)^{-1} = \begin{bmatrix} \boldsymbol{A} & \boldsymbol{b} \\ \boldsymbol{c} & d \end{bmatrix}$$

$\boldsymbol{A} \in \mathbb{R}^{(n-1)\times(n-1)}; \boldsymbol{b} \in \mathbb{R}^{(n-1)x1}$; $\boldsymbol{c} \in \mathbb{R}^{1\times(n-1)}; d \in \mathbb{R}$

Where:

$$\boldsymbol{A} = \left(\boldsymbol{K}_{t_{n-1}}\right)^{-1} + \frac{(\boldsymbol{K}_{t_{n-1}})^{-1}\boldsymbol{k}_*\boldsymbol{k}_*^T(\boldsymbol{K}_{t_{n-1}})^{-1}}{(\langle x_{t_n}, x_{t_n}\rangle) - \boldsymbol{k}_*^T(\boldsymbol{K}_{t_{n-1}})^{-1}\boldsymbol{k}_*}$$

$$\boldsymbol{b} = -\frac{(\boldsymbol{K}_{t_{n-1}})^{-1}\boldsymbol{k}_*}{(\langle x_{t_n}, x_{t_n}\rangle) - \left(\boldsymbol{k}_*^T(\boldsymbol{K}_{t_{n-1}})^{-1}\boldsymbol{k}_*\right)}$$

$$\boldsymbol{c} = -\frac{\boldsymbol{k}_*^T(\boldsymbol{K}_{t_{n-1}})^{-1}}{(\langle x_{t_n}, x_{t_n}\rangle) - \boldsymbol{k}_*^T(\boldsymbol{K}_{t_{n-1}})^{-1}\boldsymbol{k}_*}$$

$$d = \frac{1}{(\langle x_{t_n}, x_{t_n}\rangle) - \boldsymbol{k}_*^T(\boldsymbol{K}_{t_{n-1}})^{-1}\boldsymbol{k}_*}$$

Those two lemmas and corollary show that finding an inverse covariance matrix could be calculated by an iterative manner or an online algorithm. Those online Inverse covariance matrix on corollary 1, clearly get from lemma 1) and lemma 2). The Inverse of $\boldsymbol{K}_{t_n}$ can be found as well on sparse-online for Gaussian process [18].

4. NUMERICAL RESULT

The aims of the numerical experiments are comparing the time computing online and offline inverse covariance matrix and the accuracy of prediction Gaussian process by the online and offline inverse covariance matrix.

4.1 Data

As we are interested in online and real-time computation that leads to high-dimensional matrix problem, sample sizes matrix that we consider are n=10, 〖 20,50,10〗^2, 〖 〖2×10〗^2, 〖5 ×10〗^2, 〖8×10〗^2,10〗^3, 〖1.5×10〗^3. We use data of Bank Central Asia (BCA) stock price. BCA is one of the famous banks in Indonesia. The data is shown in Figure

4.2 Methodology

Performance of online and offline Inverse covariance matrix are shown by time-computing and root mean square error (RMSE) of Gaussian process. First, we do time-computing comparation of online and offline Inverse covariance matrix. Then, online predictive Gaussian process use online Inverse covariance matrix on corollary 1. Moreover, RMSE of online Inverse covariance matrix are compared to RMSE of offline Inverse covariance matrix. Offline Inverse covariance matrix is Inverse that is calculated straight from the covariance matrix. It means that offline Inverse covariance matrix calculates $\left(\boldsymbol{K}_{t_n} + \sigma_n^2 I\right)^{-1}$ by doing Inverse to matrix $\left(\boldsymbol{K}_{t_n} + \sigma_n^2 I\right)$. Meanwhile, Computation of $\left(\boldsymbol{K}_{t_n} + \sigma_n^2 I\right)^{-1}$ on Equation (1) use formula on Corollary 1, that is $\left(\boldsymbol{K}_{t_n} + \sigma_n^2 I\right)^{-1}$ is calculated from formula of $\left(\boldsymbol{K}_{t_{n-1}} + \sigma_{t_n}^2 I\right)^{-1}$. In this simulation we choose squared exponential covariance function $k(x, x') = h^2 exp\left(-\frac{|x-x'|^2}{2l^2}\right)$, where $l > 0$ is length input scale and h^2 is output scale. l and h^2 are hyperparameter that we choose. As we focused on online and offline Inverse matrix, we choose fixed hyperparameter $h^2 = 1$ and $l = 1$.

4.3 Time-Computing of Inverse Covariance Matrix

Time-computing offline Inverse covariance matrix is started since generate matrix $\boldsymbol{K}_{t_n}$ until get the Inverse covariance matrix $\left(\boldsymbol{K}_{t_n}\right)^{-1}$ given $\boldsymbol{K}_{t_{n-1}}$ and new data pair $\left(x_{t_n} y_{t_n}\right)$. Meanwhile, the time-computing online Inverse covariance matrix is time-computation of all element in Inverse covariance matrix $\boldsymbol{K}_{t_n}$ on corollary 1, given $\left(\boldsymbol{K}_{t_{n-1}}\right)^{-1}$ and new data pair $\left(x_{t_n} y_{t_n}\right)$. We do 100 times iteration to find the mean of time-computing. The Table 1 show the time-computing for online and offline Inversion in detail. Time-computing of online Inverse covariance matrix is less than offline Inverse covariance matrix, it can be seen on Figure 1. This simulation shows that online is more efficient than offline on inversion covariance matrix because online do inversion faster than offline.

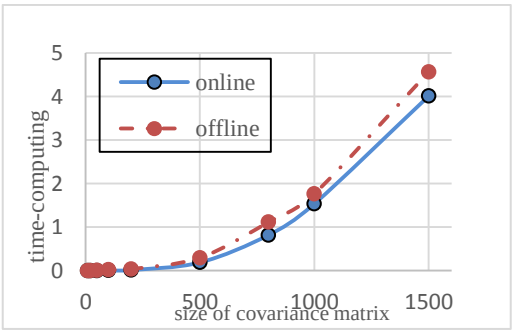

Figure 1. Time-Computing for Online and Offline Inversion of Covariance Matrix.

Table 1. Time-Computing of Online and Offline Inverse Covariance Matrix

Size of Inverse Covariance matrix (n)	Time-computing (second)	
	online	offline
10	0.000245781	0.00023216
20	0.00027442	0.00032383
50	0.0010	0.0050
10^2	0.0025	0.0200
2×10^2	0.0142	0.0370
5×10^2	0.1874	0.2957
8×10^2	0.8622	1.1143
1×10^3	1.3136	1.7646
1.5×10^3	4.0117	4.5630

4.4 RMSE Predictive Gaussian Process

Online predictive distribution of Gaussian process as on Equation (1) is running every step of new data come. RMSE are calculated after finish doing prediction as many as size of data. RMSE between online and offline predictive Gaussian process are shown on Table 2. It has been shown that RMSE is not different. Those are caused that both Inverse are almost equal. Maximum of difference element Inverse matrix by online and offline is between $10^{-12} - 10^{-16}$. For matrix size 1×10^3, it gives 4.8850×10^{-15}. Then, we can assume that Inverse by offline and online is equal. Moreover, it means that we can assume that the predictive distribution of Gaussian process by online Inverse covariance matrix is same with Gaussian process by offline Inverse covariance matrix.

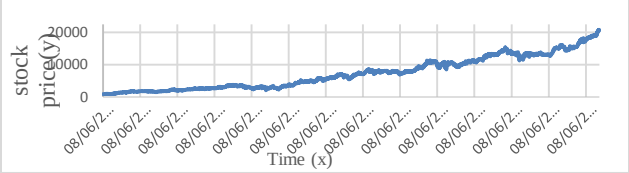

Figure 2. Bank Central Asia Stocks Close-Price since 6 August 2004 until 6 August 2017

Table 2. Root Mean Square Error (RMSE) of Online and Offline Predictive Gaussian Process

Size of data	RMSE	
	online	offline
10	17.0321	17.0321
20	13.8370	13.8370
50	12.4492	12.4492
10^2	17.6426	17.6426
2×10^2	23.9425	23.9424
5×10^2	23.5635	23.5636
8×10^2	22.5190	22.5190
1×10^3	34.3657	34.3657
1.5×10^3	50.2954	50.2954

5. CONCLUSION

The less of time-computing of an algorithm then it means the more efficient algorithm. The time-computing of an online inverse covariance matrix is less than offline that means online is more efficient than the offline. Using both methods inverse matrix results on prediction Gaussian processes shows that predictions are same. Those are caused by the same inversion covariance matrix results. It means that inversion by online more efficient time-computing than offline and preserve the predictive distribution of Gaussian process well.

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Periodic Solutions of Branched Space from Closed Orbits under Mixed Perturbations

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ABSTRACT
By combining the means of the center manifold theorem and Planar branching theory, this paper studies the sufficient conditions for general three-dimensional systems to branch out into spatial periodic solutions under mixed perturbations, and obtains two theorems for judging the periodic solutions of general three-dimensional systems branching out from closed orbits, which generalize the results of existing planar systems.

CCS Concepts
• Mathematics of computing→Mathematical analysis→Differential equations

Keywords
Mixed disturbance; branch; decision function.

1. INTRODUCTION
Consider the system

$$\begin{cases} \dfrac{dx_1}{dt} = g_1(x_1,x_2,x_3) + \lambda f_1(x_1,x_2,x_3,\lambda) \\ \dfrac{dx_2}{dt} = g_2(x_1,x_2,x_3) + \lambda f_2(x_1,x_2,x_3,\lambda) \\ \dfrac{dx_3}{dt} = g_3(x_1,x_2,x_3) + \lambda f_3(x_1,x_2,x_3,\lambda) \end{cases} \quad (1)$$

where $g_i(x_1,x_2,x_3)$ ($i=1,2,3$) is the smooth function on R^3, $f_i(x_1,x_2,x_3,\lambda)$ ($i=1,2,3$) has enough smoothness, and $f_i(0,0,0,0)=0$. Suppose $O(0,0,0)$ is the singularity of system (1), when $\lambda=0$, the coefficient matrix

$$\begin{pmatrix} \dfrac{\partial g_1}{\partial x_1} & \dfrac{\partial g_1}{\partial x_2} & \dfrac{\partial g_1}{\partial x_3} \\ \dfrac{\partial g_2}{\partial x_1} & \dfrac{\partial g_2}{\partial x_2} & \dfrac{\partial g_2}{\partial x_3} \\ \dfrac{\partial g_3}{\partial x_1} & \dfrac{\partial g_3}{\partial x_2} & \dfrac{\partial g_3}{\partial x_3} \end{pmatrix}$$

of the linearized system (1) at the singularity O has a pair of conjugate complex eigenvalues and a negative real eigenvalue. Reference [1] studies the bifurcated periodic solutions of the special planar system $\begin{cases} \dfrac{dx}{dt} = -y + \lambda f_1(x,y,\lambda) \\ \dfrac{dy}{dt} = x + \lambda f_2(x,y,\lambda) \end{cases}$. Reference [2] studies the closed-orbit bifurcation of a general planar system around a simply connected closed region. Reference [3] studies the problem of periodic solutions in bifurcation space for a special class of three-dimensional systems. In this paper, the sufficient conditions for the periodic solutions of general three-dimensional systems in bifurcation space of closed-orbit families under mixed perturbations are further given. The systems studied in references [1], [2] are extended to three-dimensional space, and the systems in references [3] are extended to general cases. An example of theorem realization is also given.

2. MAIN THEOREMS
First, let's consider the general plane system

$$\begin{cases} \dfrac{dx}{dt} = g_1(x,y) + \lambda f_1(x,y,\lambda) \\ \dfrac{dy}{dt} = g_2(x,y) + \lambda f_2(x,y,\lambda) \end{cases} \quad (2)$$

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where $f_i(x,y,\lambda)$ ($i=1,2$) has enough smoothness. Suppose $\lambda=0$, then when $t=0$, the solution $\begin{cases} x=\phi(t,A,0) \\ y=\varphi(t,A,0) \end{cases}$ of system 2 from $(0,A)$ is periodic solution $\begin{cases} x=\phi(t,A,0) \\ y=\varphi(t,A,0) \end{cases}$ within period $T(A,0)$.

Introduce the Family of Reference Curves $F(x,y,\lambda)=\frac{x^2+y^2}{2}+\lambda\sum_{k=3}^{n}F_k(x,y,\lambda)$, where $F_k(x,y,\lambda)$ is the k-degree homogeneous polynomial of x, y, and its coefficients are related to λ. It's obvious that when $|\lambda|<<1$, both $F(x,y,\lambda)=c$ and $c\in(0,c_0)$ are simple closed curves that surround the origin, and they expand monotonously with the increase of c. Note L_A as the trajectory of system (2) starting from $(0,A)$ when $t=0$, and its corresponding solution is

$$\begin{cases} x=\phi(t,A,\lambda) \\ y=\varphi(t,A,\lambda) \end{cases} \tag{2.1}$$

When $|\lambda|<<1$, according to the continuous dependence theorem of solutions on initial values and parameters[4], $T(A,\lambda)$ will make the solution of system (2) starting from $(0,A)$ return to the neighborhood of $(0,A)$ on the y axis when $t=T(A,\lambda)$. Therefore, to judge whether (2.1) is a periodic solution, we only need to check whether $\varphi(T(A,\lambda),A,\lambda)=A$ is valid. Because of the monotonicity of $F(x,y,\lambda)=c$ to c, we just need to see if

$$F(\phi(T(A,\lambda),A,\lambda),\varphi(T(A,\lambda),A,\lambda),\lambda)-F(0,A,\lambda)=0$$

is valid. The upper formula is equivalent to

$$\int_0^{T(A,\lambda)}\frac{dF(\phi(t,A,\lambda),\varphi(t,A,\lambda),\lambda)}{dt}dt=0.$$

Namely

$$\int_0^{T(A,\lambda)}[\lambda(g_1(x,y)+\lambda f_1(x,y,\lambda))\sum_{k=3}^{n}\frac{\partial F_k}{\partial x}+\lambda(g_2(x,y)+\lambda f_2(x,y,\lambda)\sum_{k=3}^{n}\frac{\partial F_k}{\partial y}+xg_1(x,y)+yg_2(x,y)+\lambda xf_1(x,y,\lambda)+\lambda yf_2(x,y,\lambda)]dt=0 \tag{2.2}$$

If x, y, is expressed by formula (2.1), $F_k=F_k(x,y,\lambda)$ can select the appropriate item according to the specific form of $F_k(x,y,\lambda)$, so that (2.2) has the form of $G(A,\lambda)=\lambda^m\int_0^{T(A,\lambda)}\{H(x,y)+\lambda R(x,y,\lambda)\}dt$ ($m\geq 0$), denoted as

$$G_1(A,\lambda)=\int_0^{T(A,\lambda)}\{H(x,y)+\lambda R(x,y,\lambda)\}dt.$$

Use the Definition to Determine the Function

$$\Phi(A)=\int_0^{T(A,0)}[H(\phi(t,A,0),\varphi(t,A,0))]dt.$$

Theorem 1 If $A_0>0$, and make $\Phi(A_0)=0$, $\Phi'(A_0)\neq 0$, then when $|\lambda|<<1$, the system (2) has periodic solution in the neighborhood of $x^2+y^2={A_0}^2$.

Proof By the definition of $G_1(A,\lambda)$, we can have $G_1(A,0)=\Phi(A)$. Then when the conditions of theorem 1 is true, according to the existence theorem of implicit functions, we can have $G_1(A,\lambda)=0$ by $A(\lambda)$ under the condition of $G(A(\lambda),\lambda)\equiv 0$, $|\lambda|<<1$, $A(0)=A_0$. That is to say, if the solution $\begin{cases} x=\phi(t,A,\lambda) \\ y=\varphi(t,A,\lambda) \end{cases}$ of (2)is a periodic solution within period $T(A(\lambda),\lambda)$ when it pass the point $(A(\lambda),0)$ with $t=0$, the proof is completed.

Let's consider a special case of system (1):

$$\begin{cases} \frac{dx_1}{dt}=g_1(x_1,x_2)+\lambda f_1(x_1,x_2,x_3,\lambda) \\ \frac{dx_2}{dt}=g_2(x_1,x_2)+\lambda f_2(x_1,x_2,x_3,\lambda) \\ \frac{dx_3}{dt}=g_3(x_1,x_2,x_3)+\lambda f_3(x_1,x_2,x_3,\lambda) \end{cases} \tag{3}$$

Denote $h_i(x_1,x_2,x_3,\lambda)=\lambda f_i(x_1,x_2,x_3,\lambda)$, then we'll have

(A): $h_i(0,0,0,0)=0,(i=1,2,3)$

(B):

$$Dh_i(0,0,0,0)=\begin{pmatrix} \frac{\partial h_1}{\partial x_1} & \frac{\partial h_1}{\partial x_2} & \frac{\partial h_1}{\partial x_3} & \frac{\partial h_1}{\partial \lambda} \\ \frac{\partial h_2}{\partial x_1} & \frac{\partial h_2}{\partial x_2} & \frac{\partial h_2}{\partial x_3} & \frac{\partial h_2}{\partial \lambda} \end{pmatrix}_{(0,0,0,0)}=0,\ (i=1,2),$$

$$Dh_3(0,0,0,0)=\begin{pmatrix} \frac{\partial h_3}{\partial x_1} & \frac{\partial h_3}{\partial x_2} & \frac{\partial h_3}{\partial x_3} & \frac{\partial h_3}{\partial \lambda} \end{pmatrix}_{(0,0,0,0)}=0;$$

According to (A), (B) and hypothesis conditions, (3) satisfies the conditions of central manifold theorem[5-7]. That is to say, there exist a local central manifold of (3) $x_3 = h(x_1, x_2, \lambda)$, which satisfies the conditions of $h(0,0,0) = 0$, $\frac{\partial h(0,0,0)}{\partial x_1} = 0$, $\frac{\partial h(0,0,0)}{\partial x_2} = 0$, $\frac{\partial h(0,0,0)}{\partial \lambda} = 0$. Besides, the set $S = \{(x_1, x_2, h(x_1, x_2, \lambda), \lambda) \mid {x_1}^2 + {x_2}^2 < \eta^2\}$ is invariant manifolds of (3).

Theorem 2 If $0 < \mathrm{A}_0 < \eta$, let $\Phi(A_0) = 0$, $\Phi'(A_0) \neq 0$, then when $|\lambda| << 1$, there will be the periodic solution of system (3) in the neighborhood of $\begin{cases} {x_1}^2 + {x_2}^2 = {A_0}^2 \\ x_3 = h(x_1, x_2, \lambda) \end{cases}$ in the invariant manifold $S = \{(x_1, x_2, h(x_1, x_2, \lambda)) \mid {x_1}^2 + {x_2}^2 < \eta^2\}$ of (3).

Proof Substitute the invariant central manifold $x_3 = h(x_1, x_2, \lambda)$ of system (3) into the first two expressions of system (3), we'll have

$$\begin{cases} \frac{dx_1}{dt} = g_1(x_1, x_2) + \lambda f_1(x_1, x_2, h(x_1, x_2, \lambda), \lambda) \\ \frac{dx_2}{dt} = g_2(x_1, x_2) + \lambda f_2(x_1, x_2, h(x_1, x_2, \lambda), \lambda) \end{cases}$$

Denote $f_i(x, y, \lambda) = f_i(x_1, x_2, h(x_1, x_2, \lambda), \lambda)$, then the above system can be formally denoted as

$$\begin{cases} \frac{dx}{dt} = g_1(x, y) + \lambda f_1(x, y, \lambda) \\ \frac{dy}{dt} = g_2(x, y) + \lambda f_2(x, y, \lambda) \end{cases}$$

Then the conclusion of theorem 2 can be obtained from the properties of invariant manifolds[8] and theorem 1.

Poof is completed.

Before we give theorem 3, we'll give a definition of separability: function pairs are said to be separable if function $g(x_1, x_2, x_3)$ can be written as a central manifold $\tilde{g}(x_1, x_2) + \lambda \tilde{g}(x_1, x_2, \lambda)$ of system $x_3 = h(x_1, x_2, \lambda)$.

According to Conditions (A) and (B), we can verify the existence of a locally invariant central manifold $S = \{(x_1, x_2, h(x_1, x_2, \lambda)) \mid {x_1}^2 + {x_2}^2 < \varepsilon^2\}$ in system (1).

Theorem 3 If in function $g_i(x_1, x_2, x_3), i = 1,2$ is separable from $x_3 = h(x_1, x_2, \lambda)$, and $0 < \mathrm{A}_0 < \varepsilon,$ makes $\Phi(A_0) = 0$, $\Phi'(A_0) \neq 0$, then when $|\lambda| << 1$, there will be the periodic solution of system (1) in the neighborhood of $\begin{cases} {x_1}^2 + {x_2}^2 = {A_0}^2 \\ x_3 = h(x_1, x_2, \lambda) \end{cases}$ in the invariant manifold $S = \{(x_1, x_2, h(x_1, x_2, \lambda)) \mid {x_1}^2 + {x_2}^2 < \varepsilon^2\}$ of system (1).

Proof Because $g_i(x_1, x_2, x_3)$ to $x_3 = h(x_1, x_2, \lambda)$ satisfies the separability, namely

$g_i(x_1, x_2, x_3) = \tilde{g}(x_1, x_2) + \lambda \tilde{g}(x_1, x_2, \lambda)$, then system (1) can be changed into

$$\begin{cases} \frac{dx_1}{dt} = \tilde{g}_1(x_1, x_2) + \lambda(f_1(x_1, x_2, x_3, \lambda) + \tilde{g}_1(x_1, x_2, \lambda)) \\ \frac{dx_2}{dt} = \tilde{g}_2(x_1, x_2) + \lambda(f_2(x_1, x_2, x_3, \lambda) + \tilde{g}_2(x_1, x_2, \lambda)) \\ \frac{dx_3}{dt} = g_3(x_1, x_2, x_3) + \lambda f_3(x_1, x_2, x_3, \lambda) \end{cases}$$

Denote

$F_i(x_1, x_2, x_3, \lambda) = f_i(x_1, x_2, x_3, \lambda) + \tilde{g}_i(x_1, x_2, \lambda), i = 1,2$,

the system (1) can be denoted as

$$\begin{cases} \frac{dx_1}{dt} = \tilde{g}_1(x_1, x_2) + \lambda F_1(x_1, x_2, x_3, \lambda) \\ \frac{dx_2}{dt} = \tilde{g}_2(x_1, x_2) + \lambda F_2(x_1, x_2, x_3, \lambda) \\ \frac{dx_3}{dt} = g_3(x_1, x_2, x_3) + \lambda f_3(x_1, x_2, x_3, \lambda) \end{cases}$$

The conclusion of theorem (3) can be obtained from theorem (2).

Proof is completed.

Theorem 3 Deduce

If $g(x_1, x_2, x_3) = \tilde{g}(x_1, x_2) \pm a{x_1}^m {x_2}^n {x_3}^k$

or $g(x_1, x_2, x_3) = \tilde{g}(x_1, x_2) \cdot a{x_1}^m {x_2}^n {x_3}^k$, where $m, n, k \in R$, and $0 < \mathrm{A}_0 < \varepsilon$, makes $\Phi(A_0) = 0$, $\Phi'(A_0) \neq 0$, then when $|\lambda| << 1$, there will be the periodic solution of system (1) in the neighborhood of $\begin{cases} {x_1}^2 + {x_2}^2 = {A_0}^2 \\ x_3 = h(x_1, x_2, \lambda) \end{cases}$ in the invariant manifold of $S = \{(x_1, x_2, h(x_1, x_2, \lambda)) \mid {x_1}^2 + {x_2}^2 < \varepsilon^2\}$ system (1).

Proof $g(x_1, x_2, x_3) = \tilde{g}(x_1, x_2) \pm a{x_1}^m {x_2}^n {x_3}^k$

$= \tilde{g}(x_1, x_2) \pm a{x^m}_1 {x_2}^n h^k(x_1, x_2, \lambda)$

$= \tilde{g}(x_1, x_2) \pm a{x^m}_1 {x_2}^n (h(x_1, x_2, 0) + \frac{\partial h(x_1, x_2, 0)}{\partial \lambda} \cdot \lambda$

$$+\cdots+\mathrm{O}(\lambda^n))^k$$

$$=\tilde{g}(x_1,x_2)\pm ax_1{}^m x_2{}^n h^k(x_1,x_2,0)\pm\lambda[(\frac{\partial h(x_1,x_2,0)}{\partial\lambda})^k\cdot\lambda^{k-1}$$

$$+\cdots+\mathrm{O}(\lambda^{nk-1})]$$

$$=g_1(x_1,x_2)+\lambda g_2(x_1,x_2,\lambda)$$

We know from the definition that the function $g(x_1,x_2,x_3)$ is separable from $x_3=h(x_1,x_2,\lambda)$.

Similarly, if $g(x_1,x_2,x_3)=\tilde{g}(x_1,x_2)\cdot ax_1{}^m x_2{}^n x_3{}^k$

$$=\tilde{g}(x_1,x_2)\cdot ax_1{}^m x_2{}^n h^k(x_1,x_2,\lambda)$$

$$=ax_1{}^m x_2{}^n\tilde{g}(x_1,x_2)(h(x_1,x_2,0)+\frac{\partial h(x_1,x_2,0)}{\partial\lambda}\cdot\lambda$$

$$+\cdots+\mathrm{O}(\lambda^n))^k$$

$$=ax_1{}^m x_2{}^n\tilde{g}(x_1,x_2)\cdot h^k(x_1,x_2,0)+\lambda[(\frac{\partial h(x_1,x_2,0)}{\partial\lambda})^k$$

$$\cdot\lambda^{k-1}\cdot\tilde{g}(x_1,x_2)+\cdots+\tilde{g}(x_1,x_2)\cdot\mathrm{O}(\lambda^{nk-1})]\cdot ax_1{}^m x_2{}^n$$

$$=g_1(x_1,x_2)+\lambda g_2(x_1,x_2,\lambda)$$

We can get that $g(x_1,x_2,x_3)$ to $x_3=h(x_1,x_2,\lambda)$ is also separable. So the deduce is established according to theorem 3.

Proof is completed.

3. EXAMPLES OF APPLICATION

Consider the branching of limit cycles for a three-dimensional quadratic system [9]

$$\begin{cases}\dfrac{dx_1}{dt}=x_3-x_2+\lambda(\omega_0\lambda^2x_1+x_1x_2+5x_3)\\ \dfrac{dx_2}{dt}=x_1+x_3+\lambda(x_1{}^2-2\lambda x_1x_2+x_3)\\ \dfrac{dx_3}{dt}=-x_3+\lambda(x_1{}^2+x_2{}^2+x_3)\end{cases}\tag{4}$$

Solution Based on examination, if (4) satisfies the condition of the central manifold theorem, then a Local Central Manifold $x_3=h(x_1,x_2,\lambda)$ of (4) exists.

Suppose $h(x_1,x_2,\lambda)=\sum_{k=2}^{n}h_k(x_1,x_2,\lambda)$, where $h_k(x_1,x_2,\lambda)$ is the k-degree homogeneous multinomial of x_1, x_2, λ, and substitute it into the differential equation satisfied by invariant manifold, we'll have

$$x_3=h(x_1,x_2,\lambda)=-\lambda^2x_1{}^2-\lambda^2x_2{}^2+\mathrm{O}(h_5(x_1,x_2,\lambda))$$

by comparing coefficient, where $h_5(x_1,x_2,\lambda)$ is 5-degree homogeneous multinomial of x_1, x_2, λ.

Take its fourth approximation expression

$$x_3=h(x_1,x_2,\lambda)=-\lambda^2x_1{}^2-\lambda^2x_2{}^2,$$

where $g_i(x_1,x_2,x_3)\ \ (i=1,2)$ is obviously separable from $x_3=h(x_1,x_2,\lambda)$. Substitute $x_3=h(x_1,x_2,\lambda)$ into the first two formulas of (4), and we can reorganize it into

$$\begin{cases}\dfrac{dx}{dt}=-y+\lambda(\omega_0\lambda^2x-5\lambda^2x^2-5\lambda^2y^2-\lambda x^2-\lambda y^2+xy)\\ \dfrac{dy}{dt}=x+\lambda(-\lambda^2x^2-\lambda^2y^2-\lambda x^2-\lambda y^2+x^2-2\lambda xy)\end{cases}$$

Using Formal Series Method[10], let

$F(x,y,\lambda)=\dfrac{x^2+y^2}{2}+\lambda\sum_{k=3}^{n}F_k(x,y,\lambda)$,we can have

$$F(x,y,\lambda)=\frac{x^2+y^2}{2}-(\lambda^2+\lambda)x^3+(5\lambda^2+\lambda)x^2y$$

$$-(\lambda^2+\lambda)xy^2+(5\lambda^2+\frac{5}{3}\lambda)y^3$$

After calculating, we can obtain function

$$G(A,\lambda)=\lambda^3\int_0^{T(A,\lambda)}\{\omega_0x^2+7x^4-5x^3+23x^2y^2-4y^4$$

$$-5x^3-5x^2y-x^2y-y^3+\lambda R(x,y,\lambda)\}\,|_{\substack{x=A\cos t\\ y=A\sin t}}\,dt,$$

$$\Phi(A)=A^2\pi[\omega_0+8A^2].$$

If we choose $\omega_0=-8r^2$, and $\Phi(A)=8A^2\pi[A^2-r^2]$, then $\Phi(r)=0$, $\Phi'(r)=16\pi r^3\neq 0$. Therefore, when $|\lambda|<<1$, system (4) has periodic solutions in its neighborhood of $\begin{cases}x_1{}^2+x_2{}^2=r^2\\ x_3=-\lambda^2(x_1{}^2+x_2{}^2)\end{cases}$ according to theorem 3.

By combining the means of the center manifold theorem and Planar branching theory, this paper studies the sufficient conditions for general three-dimensional systems to branch out into spatial periodic solutions under mixed perturbations[11] and the correctness of the conclusion is also verified by the example we constructed. In addition, the concept of separability proposed in this paper will be further improved to expand the scope of its application.

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Mathematical Critical Thinking and Creative Thinking Skills: How Does Their Relationship Influence Mathematical Achievement?

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ABSTRACT
This paper examines the correlation of mathematical critical thinking and creative thinking skills towards students' mathematical achievements. A total of 115 eighth grade students from three schools in Sleman Regency were involved as the subject of this research. Data were obtained from the results of critical thinking skills test, the results of creative thinking skills test, and the results of mathematical achievement test on the learning material that students had studied in the previous semester. The instrument for testing critical thinking skills was the essay questions which measure the aspects of critical thinking skills, namely inference, analysis, evaluation, and interpretation, while the instrument for creative thinking skills test was also the essay questions which measure the aspects of creative thinking skills, namely originality, flexibility, and fluency. Besides, the data for the students' mathematical achievements were obtained from the report of mathematics achievement test prepared by the Mathematics Teachers' Working Group. The correlation of these variables was analyzed through multiple regression test. The analysis resulted a positive relationship between the mathematical critical thinking and creative thinking skills towards the mathematical achievement indicated by the regression coefficient $R = 0.721$ and $R^2 = 0.52$. These values showed that the influence of mathematical critical thinking and creative thinking skills on the students' mathematical achievements was 52%, whereas 48% was influenced by other factors. Then, the coefficient value of creative thinking variable was $\widehat{\beta_1} = 0.363$ and the coefficient value of critical thinking variable was $\widehat{\beta_2} = 0.477$. These values indicated that if the creative thinking skill increases by one unit, the mathematical achievement increases by 0.363, on the other hand, if the critical thinking skill increases by one unit, the mathematical achievement increases by 0.477.

CCS Concepts
• Social and professional topics→Professional topics→ Computing education→ Student assessment

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Keywords
Critical Thinking; Creative Thinking; Relationship; Mathematics Achievement; Multiple Regression.

1. INTRODUCTION
To succeed in a life where everything keeps growing, good thinking skills can help people make reliable decisions and acquire new knowledge quickly [1]. Therefore, it is very appropriate if education emphasizes learning that devotes effort to teach students how to think [2], particularly how to think critically and to think creatively [1, 3,4,5,6,7]

Critical thinking includes skills of analyzing arguments, making conclusions using inductive or deductive reasoning, evaluating, and making decisions or solving problems [8]. An individual who has critical thinking skills is like having a set of tools, instruments, techniques, and capacities to handle items (including the skills to identify when and what other tools are needed). Further, the critical thinkers think based on rational thinking so they are able to provide evidence and reasons for the opinions that they convince about [9], whereas the creative thinking is shown through different thoughts and requires the elaboration of ideas that are many, varied and unique [10]. Someone who has the skills to think creatively tends to be able to be flexible when dealing with real-life situations [11] so as to be able to produce creative solutions needed in facing new challenges [12]. Thus, critical thinking and creative thinking skills must be part of learning and the schools must be responsible for developing and evaluating these two main skills through the teaching and learning process.

The importance of critical thinking and creative thinking skills in the education field has led to many studies that investigate both the relationship with other variables and the steps in developing these two skills. This emphasizes that both critical thinking and creative thinking skills are important elements to succeed in mathematics. Another variable which is interesting to be studied between those variables is mathematical achievement, because mathematical achievement is the result of student's performance in mathematics [13]. Several previous research findings concluded that mathematical creativity scores can predict mathematical achievements [14,15]. More importantly, the results of the researches on critical thinking skills also revealed the same result that the development of critical thinking skills can improve mathematical achievement [16,13,17,18]. From the results of these studies, a question arises as to how the two main skills relate to mathematical achievement. Hence, this study attempts to examine the relationship of critical thinking and creative thinking skills on students' mathematical achievements.

2. RESEARCH METHOD

As mentioned earlier, this article analyzes the relationship of mathematical critical thinking and creative thinking skills of junior high school students on their mathematical achievements. Four classes of eighth grade students from three different schools participated in this study where the three schools were the representatives of each school with high, medium and low categories based on the results of the 2018 national mathematics exam. The researchers chose one class from a high category school, two classes from a medium category school, and one class from a low category school. A total of 115 students consisting of 52 male students and 63 female students were selected as samples through stratified random sampling.

The data of students' mathematical critical thinking and creative thinking skills were collected through written tests consisting of four essay questions to measure critical thinking skills and three essay questions to measure creative thinking skills in which these questions were related to the learning material that the students had learned in the previous semester. Through critical thinking tests, the students were analyzed for the aspects of critical thinking skills, namely aspects of inference, analysis, evaluation, and interpretation, while the test of creative thinking measures the aspects of originality, flexibility, and fluency. Before the implementation of the test, the instruments for critical thinking test and creative thinking test were validated by three expert judgments and both tests passed the trial phase. Reliability in this study was indicated by Cronbach's alpha value of 0.778 for critical thinking test and 0.75 for creative thinking test, while the data of students' mathematical achievement were obtained through information from the subject matter teachers. The instruments measuring the mathematical achievements of the four classes were compiled by the Mathematics Teachers' Working Group of Sleman Regency, Indonesia. Therefore, even though the students come from three different schools, they had the same achievement test in that the instruments had the same learning materials used for the test of critical thinking and creative thinking skills.

The researchers analysed the results by categorizing the results of students' mathematical achievement tests into five categories, namely very high, high, medium, low, and very low. This categorization was adapted from Widoyoko's theory. Furthermore, both the results of the students' critical thinking and creative thinking skills were also categorized into the same five categories. Then, analysis was carried out by testing the relationship of critical thinking and creative thinking skills on students' mathematical achievements through multiple regression tests using SPSS version 20 (a software package used for statistical analysis).

3. RESULT & DISCUSSION

3.1 Students' Mathematical Achievements

In this study, students' mathematical achievements were obtained from the subject matter teachers' reports of the previous mathematical achievement test where the same learning materials were also used in critical thinking tests and critical thinking tests. In addition, the use of the same mathematical achievement instruments for all junior high schools in this region is a reinforcing reason that these data were appropriate as a standard for students' mathematical achievements. Based on the data on mathematical achievements, the students were grouped into five categories as presented in Table 1.

Table 1. Criteria and results of categorizing mathematical achievements

Interval Skor	Criteria	%	n	SD
$x > x_i + 1{,}9sd_i$	Very High	4,35	5	18,67
$x_i + 0{,}9sd_i < x \leq x_i + 1{,}9sd_i$	High	26,09	30	
$x_i + 0{,}1sd_i < x \leq x_i + 0{,}9sd_i$	Average	22,61	26	
$x_i - 1{,}2sd_i < x \leq x + 0{,}1sd_i$	Low	30,43	35	
$x \leq x_i - 1{,}2sd_i$	Very Low	16,52	19	

Based on the data in Table 1, it can be seen that the samples of this study were students with diverse mathematical achievements with low math achievement category more dominant than other categories.

3.2 Students' Mathematical Critical Thinking Skill and Creative Thinking

Similar to mathematical achievements, the results of students' critical thinking and creative thinking skills tests were also categorized into five categories. The following are the table for the results of students' critical thinking and creative thinking skills and their categorization.

Table 2. The results of categorizing mathematical critical thinking skill and its category

Interval Skor	Criteria	%	n	SD
$x > x_i + 1{,}9sd_i$	Very High	0	0	17, 14
$x_i + 0{,}9sd_i < x \leq x_i + 1{,}9sd_i$	High	13,04	15	
$x_i + 0{,}1sd_i < x \leq x_i + 0{,}9sd_i$	Average	26,09	30	
$x_i - 1{,}2sd_i < x \leq x + 0{,}1sd_i$	Low	40	46	
$x \leq x_i - 1{,}2sd_i$	Very Low	20,87	24	

Table 3. The results of categorizing mathematical creative thinking and its category

©Interval Skor	Criteria	%	n	SD
$x > x_i + 1{,}9sd_i$	Very High	3,48	4	20,2 6
$x_i + 0{,}9sd_i < x \leq x_i + 1{,}9sd_i$	High	2,61	3	
$x_i + 0{,}1sd_i < x \leq x_i + 0{,}9sd_i$	Average	17,39	20	
$x_i - 1{,}2sd_i < x \leq x + 0{,}1sd_i$	Low	35	35	
$x \leq x_i - 1{,}2sd_i$	Very Low	54	54	

Seen in Table 2, there were no students belonged to very high category for critical thinking skills. It means that most students were in the low category. Surprisingly, as seen in Table 3, the

categories of students' creative thinking spread from very high to very low, however dominantly, the students' skills belonged to lower category.

3.3 The Influence of Critical Thinking Skill and Creative Thinking on Students' Mathematical Achievements

To find out the relationship of mathematical critical thinking and creative thinking skills on students' mathematical achievements, multiple regression analysis was used in this study. The critical thinking skill and creative thinking are independent variables and mathematical achievement is the dependent variable. The multiple regression model in this study can be seen in Figure 1.

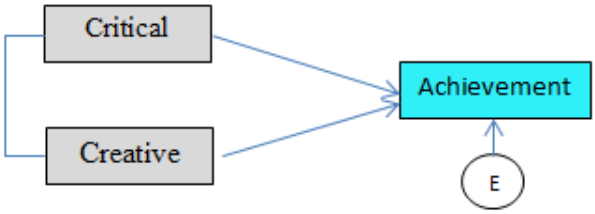

Figure 1. Multiple regression conceptual framework

Two tests were carried out in multiple regression, namely the classic assumption test and the feasibility test of the model. The classic assumption test revealed that the data meets the normality test, linearity test, heteroxedacity test, multicollinearity test, and autocorrelation test, so that the analysis can be continued with the feasibility test of the model. The feasibility test of the model used the F-test. The results of the ANOVA F-test can be seen in Table 4 below.

Table 4. ANOVA F-test results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20672,468	2	10336,234	60,658	,000[b]
	Residual	19084,923	112	170,401		
	Total	39757,391	114			

a. Predictors: (Constant), Critical, Creative

b. Dependent Variable: Achievement

Table 4 above showed a significance value of 0.000 which is smaller than the significance level of 0.05 so that the linear regression model is used to explain the relationship between critical thinking and creative thinking skills on mathematical achievement.

After the F-test, the coefficient of correlation test was carried out through t-test. The following are the results of the t-test in this study.

Table 5. T-test results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	18,512	3,430		5,397	,000		
	Creative (X1)	,363	,070	,394	5,158	,000	,736	1,359
	Critical (X2)	,473	,083	,435	5,694	,000	,736	1,359

a. Dependent Variable: Achievement (Y)

Table 5 showed that the regression coefficient value $(\widehat{\beta_1})$ is equal to 0.363 with a significance value of 0.000 and a regression coefficient value $(\widehat{\beta_2})$ amounts to 0.473 with a significance value of 0.000. Based on these results, it can be concluded that there is a relationship between the critical thinking and creative thinking skills skills on the students' mathematical achievements. Then, the coefficient of determination was calculated to explain the variations in the influence of critical thinking and creative thinking skills on mathematical achievements. To see the value of the coefficient of determination using the R-square value, Table 6 was presented in the following.

Table 6. Summary for the determination coefficient

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,721[a]	,520	,511	13,054	1,120

a. Predictors: (Constant), Critical (X2), Creative (X1)

b. Dependent Variable: Achievement (Y)

Seen from the R-square value in the table above which is 0.520, it showed that the proportion of the influence of the critical thinking skill and creative thinking on mathematical achievements is 52%. This means that the skills to think critically and think creatively has a proportion of influence on mathematics achievements by 52% while the remaining 48% is influenced by other variables not examined by researchers.

After estimating the multiple regression model and testing the fulfilment of the requirements both in the classic assumption test and the feasibility test of the model, the researchers interpreted the results. The interpretation of the model can be seen in Table 7.

Table 7. Model interpretation

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	18,512	3,430		5,397	,000		
	Creative (X1)	,363	,070	,394	5,158	,000	,736	1,359
	Critical (X2)	,473	,083	,435	5,694	,000	,736	1,359

a. Dependent Variable: Achievement (Y)

From the table above, the multiple linear regression equation has been estimated below.

$$Y=18,512 + 0,363X_1 + 0,473X_2 + e$$

or

$$\text{Achievement} = 18,512 + 0,363\text{Creative} + 0,473\text{Critical} + e$$

The regression coefficient of creative thinking variable is 0.363 and the critical thinking skill variable is 0.473. The regression coefficient of creative thinking is positive, meaning that when the students' mathematical creative thinking skills increase, the students' mathematical achievements also increase, as well as when the students' mathematical creative thinking decreases, the students' mathematical creative thinking skills also decrease. This result is in accordance with the previous research which indicated that the students who applied creative thinking to learn mathematics have consequences for better achievement in curriculum-based mathematics exams and vice versa [4,19].

The regression coefficient of critical thinking skill variable of 0.473. Similar to the regression coefficient of creative thinking, coefficient of critical thinking variable is positive, which means that when the students' mathematical critical thinking skills arise, the students' mathematical achievements also increase and vice versa. This is in line with the previous research concluded that critical thinking is an important concept in improving achievement, especially in mathematics [17,18].

It is undeniable that high mathematical achievements were subjected to mathematics learning in general, however through this research it is hoped that the results can become a benchmark for teachers in improving mathematical achievements. The teachers might not use pedagogical approach that focuses on factual recall and procedural understanding, but they can emphasize the learning that involves critical thinking skill and creative thinking. The 52% proportion of mathematical achievements is not a small proportion but a proportion that increasingly reinforces critical thinking and creative thinking skills as important skills involved in learning and curricula through contexts, activities and questions in school subjects, particularly mathematics [3]. Thus, the teacher's efforts in maximizing both critical thinking and creative thinking are highly expected, so that the students are able to achieve maximum achievement. Further research is needed to verify this relationship using the measures of critical thinking, creative thinking, and academic achievement in other fields of study and across other countries, to establish whether similar findings will be found out in other settings and contexts.

4. CONCLUSION

This study provides empirical support for the relationship between critical thinking and creative thinking skills on students' mathematical achievements. The influence of critical thinking and creative thinking skills is 52% and there might be 48% of other factors not examined by researchers that influence students' mathematical achievements. the contribution of the critical thinking skills on the students' mathematical achievements was 0.473 while the contribution of creative thinking skills on the students' mathematical achievements was 0.363. These results indicated that the drive for critical thinking and creative thinking in mathematics is important for the development of mathematical achievements.

5. ACKNOWLEDGEMENT

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Influence of Natural Endowment of Users on the Safety of Household Appliances Based on the Consumer Survey

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ABSTRACT
A survey of basic information of consumers, attention of respondents to basic information of electrical appliances, attention of respondents to the safety indicators of household appliances and the purchase channels of respondents through questionnaire was conducted. The correlation between age of respondent, education background and occupation and purchase channels are analyzed as well as attention to the safety indicators of household appliances. Goodness of fit and correlation coefficient was used to analyze and test. The results show that there is a significant relationship between occupation, age and purchase channel as well as between occupation, education background, age and safety indicators of electrical appliances.

CCS Concepts
• Social and professional topics→User characteristics→ Cultural characteristics

Keywords
Correlation; housed appliances; consumers; natural endowment

1. INTRODUCTION
Consumer behavior research has always been on economic behaviors in daily life. Many scholars have done a lot of research on consumer behaviors from the perspective of economic theory [1]. The endowment characteristics of consumers, e.g. age, education background and gender, will have a certain impact on the products selected, and consumers with different endowments will pay different attention to the quality and safety of products. Scientific understanding of consumption characteristics of consumers and full understanding of the impact mechanism of consumer endowment on consumer product selection and focus is conducive to providing theoretical support for the formulation of reasonable consumer product safety management policies and measures [2, 3]. This paper intends to analyze the relationship between the purchase channels of respondents for electrical products and concerns of safety indicators and their endowments.

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2. SURVEY PLAN AND RESULTS

2.1 Survey Plan
This survey was conducted with the help of so-jump. 439 questionnaires were distributed and returned. All questionnaires were effective. The contents of the questionnaire include the basic information of respondents, attention of respondents to the basic information of electric appliances, the purchase channels of respondents, the possibility of injury during use of products, the source of accident information, etc.

2.2 Analysis of Survey Results
2.2.1 Personal information of respondents
The personal information of respondents mainly includes the age, gender, education level and occupation of respondents. The survey results show that the ages of respondents are mainly between 18 and 50 years old, and most of the undergraduates have a bachelor degree and are company staff, professionals (teachers/doctors/lawyers, etc.), public institutions/civil servants/government staff and students, which indicates that the respondents have a high educational level. The specific distribution is as shown in table 1 to table 4.

Table 1. Age distribution of respondents

Option	Subtotal	Proportion
1. Under 18	0	0%
2. 18 to 25	124	28.25%
3. 25 to 35	224	51.03%
4. 35 to 50	81	18.45%
6. 50 to 65	10	2.28%
7. Above 65	0	0%

Table 2. Gender distribution of respondents

Option	Subtotal	Proportion
1. Male	192	43.74%
2. Female	247	56.26%

2.2.2 Attention of respondents to product information
This questionnaire is based on the situations that consumers purchase electronic and electrical products. After extensive understanding about concerns of consumers for the purchase of electronic and electrical products, the information related to

products is divided into brand, material, safety performance, comprehensiveness of functions, convenience, 3C certification mark [4, 5]. Factory name, factory address, qualified certification mark, place of origin –domestic, place of origin –abroad, price and other categories. The distribution is as shown in table 5.

Table 3. Distribution of education backgrounds of respondents

Option	Subtotal	Proportion
1. Junior high school and below	5	1.14%
2. Senior high school/ secondary school/ technical school	12	2.73%
3. Junior college	70	15.95%
4. Undergraduate	320	72.89%
5. Postgraduate and above	32	7.29%

Table 4. Distribution of occupations of respondents

Option	Subtotal	Proportion
1. Professionals (teachers/doctors/lawyers, etc.)	59	13.44%
2. Service industry personnel (food entering staff/drivers/sales staff, etc.)	24	5.47%
3. Freelancers (writers/artists/photographers/guides, etc.)	19	4.33%
4. Workers (e.g. factory workers/construction workers/urban sanitation workers, etc.)	13	2.96%
5. Company staff	223	50.8%
6. Public institutions/civil servants/government staff	48	10.93%
7. Students	45	10.25%
8. Housewives	5	1.14%
9. Retirement	1	0.23%
10. Others	2	0.46%

Table 5. Concerns of respondents on product information

Option	Subtotal	Proportion
Brand (fill in the brand name you are interested in):	162	36.9%
Material	243	55.35%
Safety performance	396	90.21%
Comprehensiveness of functions	315	71.75%
Convenience	157	35.76%
3C certification mark	230	52.39%
Factory name, factory address, qualified certification mark	225	51.25%
Place of origin – domestic	80	18.22%
Place of origin -国内 abroad	39	8.88%
Price	288	65.6%
Others	3	0.68%

2.2.3 Attention of respondents to the safety indicators of household appliances

This questionnaire is based on extensive collection and analysis of domestic appliances related domestic and international recall notifications, public opinion analysis and VR simulation experiments and includes options of leakage protection, fire prevention, short-circuit protection, mechanical stability, sharp edges and sharp corners, and presence, extrusion point, child safety lock, suction strength of refrigerator door, high temperature, low temperature, privacy protection, and other options related to electrical safety indicators, the distribution of which is as shown in table 6.

Table 6. Attention of respondents to safety indicators of household appliances

Option	Subtotal	Proportion
Leakage protection	389	88.61%
Fire prevention	256	58.31%
Short-circuit protection	318	72.44%
Mechanical stability	274	62.41%
Sharp edges and sharp corners	252	57.4%
Extrusion points	117	26.65%
Child safety lock	146	33.26%
Suction strength of refrigerator door	166	37.81%
High temperature	160	36.45%
Low temperature	106	24.15%
Privacy protection	91	20.73%
Others	1	0.23%

2.2.4 Purchase channels of respondents

Current common purchase channels of household appliances: specialty store, large store/shopping mall, small commodity wholesale market, shopping online, chain hypermarket, small supermarket, street vendor and others. The distribution is as shown in table 7. It can be seen that the respondents mainly purchase household appliances in specialty stores, large stores/shopping malls, shopping online and chain hypermarket.

Table 7. Purchase channels of respondents

Option	Subtotal	Proportion
Specialty store	362	82.46%
Large store/shopping mall	373	84.97%
Small commodity wholesale market	30	6.83%
Shopping online	294	66.97%
Chain hypermarket	195	44.42%
Small supermarket	27	6.15%
Street vendor	4	0.91%
Others	1	0.23%

3. CORRELATION ANALYSIS

3.1 Correlation Analyzing

3.1.1 Data visualization

The data is visualized first before correlation analysis so as to visually display the relationship between occupation, education background and age of respondents and purchase channel [6-8], as shown in figure 1 to figure 3.

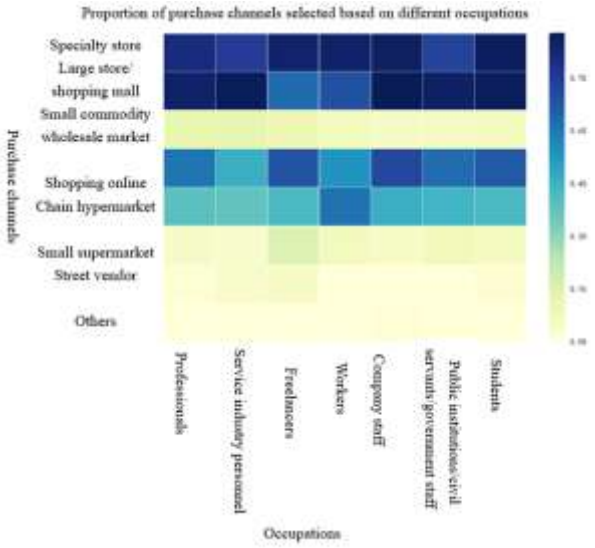

Figure 1. Relationship between occupations of respondents and purchase channels

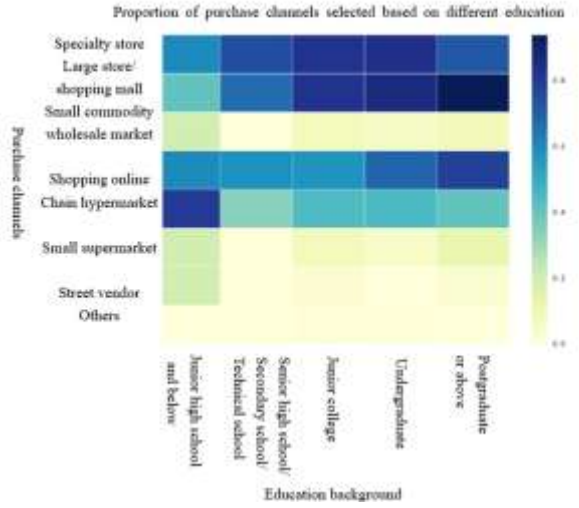

Figure 2. Relationship between education background of respondents and purchase channel

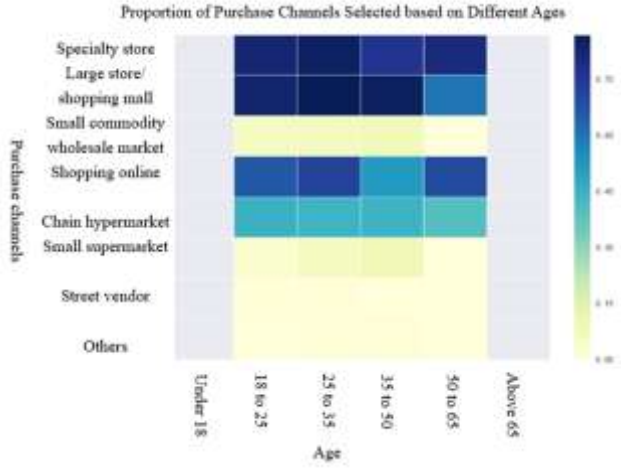

Figure 3. Correlation between age of respondents and purchase channels

It can be seen from figure 1 to figure 3 that the correlation analysis based on "occupation, education background and age of respondents" show that most of the respondents choose to purchase in specialty stores and large stores/shopping malls, followed by online purchase and purchase at chain hypermarkets. It can be seen from figure 2 that more and more people will choose to purchase household appliances in "large stores/shopping malls" or on the Internet. However, it is seen from the overall perspective that the change of purchasing channels is not obviously effected by the "occupation, education background and age of respondents" (the color change range of each line is not large). Therefore, it can be preliminarily judged that the correlation between age, education background and occupation of respondents and purchase channel is not obvious.

3.1.2 Goodness of fit test

Goodness of fit test is one of the important contents of statistical significance test by χ^2 statistical magnitude. The expected frequency of each category between categorical variables is calculated based on the overall distribution. It is compared with separated observed frequency t judge whether there is a significant difference between the expected frequency and the observed frequency so as to achieve the purpose of analyzing the categorical variables [8-10].

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

$$f_e = \frac{RT * CT}{n}$$

Where, f_o refers to observed value frequency; f_e refers to the expected value of frequency in a given unit; RT refers to the total for the row of given unit; CT refers to the total for the column of given unit; n refers to the total number of observed values, i.e. sample size.

The test results of goodness of fit for the age, education background and occupation of respondents and purchase channels are as shown in table 8.

Table 8. Goodness of fit test results

Items	Occupation	Education Background	Age
χ^2	28.7999	41.5782	9.5480
p-value	0.9397	0.0475	0.7944

It can be seen from table 8 that there is a significant relationship between occupation and age and purchase channel.

3.1.3 Correlation coefficient

The statistical test of correlation between two categorical variables based on χ^2 distribution has been discussed above. The next step is to discuss the correlation degree of two variables if they were related before. Here, column correlation coefficient and v correlation coefficient are used to measure the correlation degree. The results are as shown in table 9.

It can be seen from table 9 that although there is a significant relationship between occupation and purchase channel, the

closeness of this relationship is not high. This means that the purchase channel is not determined by only one categorical variable.

Table 9. Correlation degree measurement

Items	Column correlation coefficient	v correlation coefficient
Correlation between age and purchase channel	0.1058	0.0752
Correlation between occupation and purchase channel	0.1491	0.0616

3.2 Correlation Analyzing

3.2.1 Data visualization

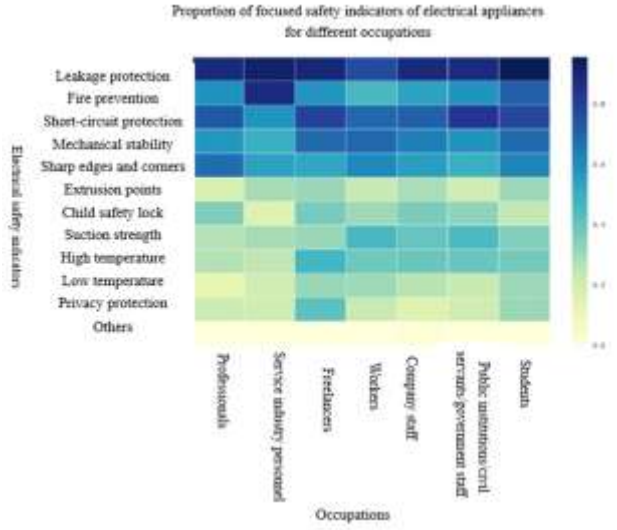

Figure 4. Relationship between position and focused safety indicators of electrical appliances

The data is visualized first before correlation analysis so as to visually display the relationship between occupation, education background and age of respondents and attention to safety indicators of electrical appliances, as shown in figure 4 to figure 6.

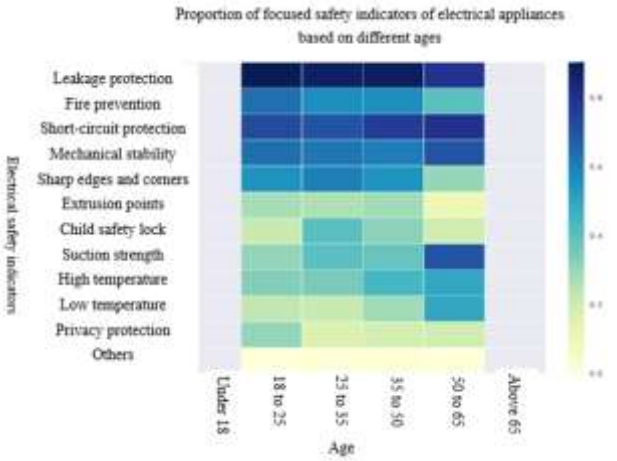

Figure 5. Relationship between age and focused safety indicators of electrical appliances

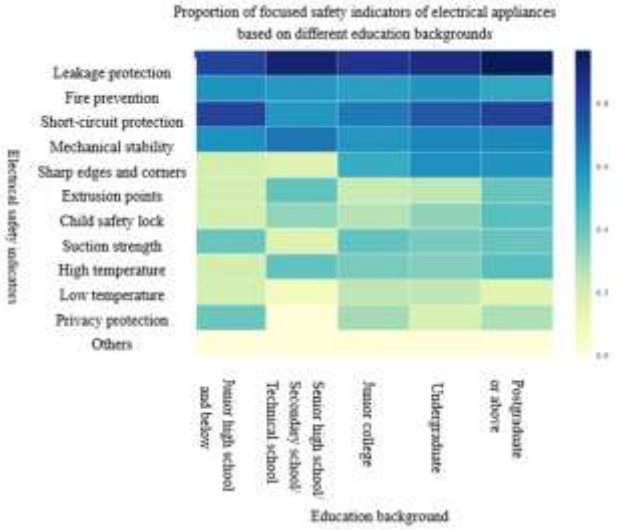

Figure 6. Correlation between education background and indicators of electrical appliances

It can be seen from figure 4 to figure 6 that most of respondents pay more attention to electrical leakage protection, fire prevention and short-circuit protection for correlation analysis respectively based on "age, education background and age". However, it is seen from the overall perspective that the focuses do not change obviously affected by the "occupation, education background and age of respondents" (the color change range of each line is not large). It can be seen from figure 5 that more and more people will choose to purchase household appliances in "large stores/shopping malls" or on the Internet. However, it is seen from the overall perspective that the change of purchasing channels is not obviously effected by the "occupation, education background and age of respondents" (the color change range of each line is not large). Therefore, it can be judged that the correlation between age, education background and occupation of respondents and purchase channel is not obvious.

3.2.2 Goodness of fit test

The test results of goodness of fit for the age, education background and occupation of respondents and safety indicators of electrical appliances are as shown in table 10.

Table 10. Goodness of fit test results

Items	Occupation	Education Background	Age
χ^2	37.7797	25.9548	24.805
p-value	0.9980	0.9862	0.3065

It can be seen from table 10 that there is a significant relationship between occupation, education background and age and safety indicators of electrical appliances.

3.2.3 Correlation coefficient

The column correlation coefficient and v correlation coefficient are used to measure the correlation degree. The results are as shown in table 11.

It can be seen from table 11 that although there is a significant relationship between occupation, education background and age and safety indicators of electrical appliances and education background is closely related to the age and safety indicators of

electrical appliances, it is not close enough. This means that the safety indicators of electrical appliances are not determined by only one categorical variable.

Table 11. Correlation degree measurement

Items	Column correlation coefficient	v correlation coefficient
Correlation between occupation and safety indicators of electrical appliances	0.0211	0.0086
Correlation between education background and safety indicators of electrical appliances	0.1286	0.0529
Age and safety indicators of electrical appliances	0.1038	0.0738

4. CONCLUSIONS

Questionnaires are distributed to survey the basic information of consumers, attention of respondents to the basic information of electrical appliances, attention of respondents to the safety indicators of electrical appliances as well as the purchase channel of respondents, and the survey results are statistically analyzed. The ages of respondents are mainly between 18 and 50; most of them are undergraduates and company staff, professionals (teachers/doctors/lawyers, etc.), public institutions/civil servants/government staff and students, which indicates that the respondents have a high educational level. Focuses of respondents for products are mainly on product safety performance, comprehensiveness of functions and price. Focuses of respondents for safety indicators of household appliances are mainly on electrical leakage protection, short-circuit protection, mechanical stability, sharp edges and corners and fire prevention. The respondents purchase electrical appliances mainly from special stores, large stores/shopping malls, on-line shopping and chain hypermarkets.

This paper analyzes the correlation between age, education background, occupation and purchase channel of respondents and attention to safety indicators of electrical appliances, and uses goodness of fit and correlation coefficient for analysis and test; there is a significant relationship between occupation, education background and age and safety indicators of electrical appliances, but it is not much too close, which shows that the purchase channels and the safety indicators of electrical appliances are not determined by only one categorical variable.

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