國家科學及技術委員會補助專題研究計畫報告

科技教具之性別可供性分析與軟硬體性別重構工程(L01)

報 告 類 別 ： 成果報告
計 畫 類 別 ： 個別型計畫
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執 行 期 間 ： 110年08月01日至111年07月31日
執 行 單 位 ： 國立高雄師範大學軟體工程系

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本研究具有政策應用參考價值：■否 □是，建議提供機關
（勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
本研究具影響公共利益之重大發現：□否 □是

中 華 民 國 111 年 10 月 31 日

中 文 摘 要 ： 許多應用程序已被應用到網際網路的工具集中，然而，很少有研究人員關注多性別學習者的感受。如何確認現有的教育工具集設計能夠滿足多性別學習視角，並提供積極的學習感受確實是必要和合理的。 我們提出了一套工具集，myKLA 和 myKLA2。在軟體性別無關之原則下，採用網宇實體信息系統理論重構功能項目，希望改造後的工具集能夠滿足具有多種性別屬性的使用者的需求。我們通過一系列功能和性能調整過程修改了我們的工具集。此外，希望研究成果可以成為其他教育工具開發和設計的參考工具集。

中 文 關 鍵 詞 ： 性別無關；知識分享；軟體設計；網頁應用程式

英 文 摘 要 ： Many applications have been derived into toolsets in the Internet. However, few researchers have paid much attention to the feeling of learners of multiple genders. How to confirm that the existing educational toolsets design would meet the multi-sex learning perspectives and provide positive learning feelings is indeed necessary and legitimate. We proposed a set of toolsets, myKLA and myKLA2. We adopt the cyber-physical system theory on software gender-free reconstruction projects and hope that the transformed toolsets can meet the needs of users with multiple gender attributes. We revised our toolsets through a series of the feature and performance tuning processes. Further, we hope that the research results can become a reference toolsets for the development and design of other educational tools.

英 文 關 鍵 詞 ： Gender-free, knowledge sharing, software design, web-based application

附件一

科技部補助專題研究計畫報告

科技教具之性別可供性分析與軟硬體性別重構工程(L01)

報告類別：□進度報告

■成果報告：■完整報告/□精簡報告

計畫類別：■個別型計畫　□整合型計畫

計畫編號：MOST 110－2629－E－017－001－

執行期間：110 年 08 月 01 日至 111 年 07 月 31 日

執行機構及系所：國立高雄師範大學軟體工程與管理學系

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本計畫除繳交成果報告外，另含下列出國報告，共 ___ 份：

□執行國際合作與移地研究心得報告

□出席國際學術會議心得報告

□出國參訪及考察心得報告

本研究具有政策應用參考價值：　■否　□是，建議提供機關________ (勾選「是」者，請列舉建議可提供施政參考之業務主管機關) 本研究具影響公共利益之重大發現：■否　□是

中　華　民　國 111 年 10 月 30 日

Catalog

1. Abstract and Keywords

1.1. Chinese Abstract and Keywords

許多應用程序已被應用到網際網路的工具集中，然而，很少有研究人員關注多性別學習者的感受。如何確認現有的教育工具集設計能夠滿足多性別學習視角，並提供積極的學習感受確實是必要和合理的。我們提出了一套工具集，myKLA 和 myKLA2。在軟體性別無關之原則下，採用網宇實體信息系統理論重構功能項目，希望改造後的工具集能夠滿足具有多種性別屬性的使用者的需求。我們通過一系列功能和性能調整過程修改了我們的工具集。此外，希望研究成果可以成為其他教育工具開發和設計的參考工具集。

關鍵字：性別無關；知識分享；軟體設計；網頁應用程式

1.2. English Abstract and Keywords

Many applications have been derived into toolsets in the Internet. However, few researchers have paid much attention to the feeling of learners of multiple genders. How to confirm that the existing educational toolsets design would meet the multi-sex learning perspectives and provide positive learning feelings is indeed necessary and legitimate. We proposed a set of toolsets, myKLA and myKLA2. We adopt the cyber-physical system theory on software gender-free reconstruction projects and hope that the transformed toolsets can meet the needs of users with multiple gender attributes. We revised our toolsets through a series of the feature and performance tuning processes. Further, we hope that the research results can become a reference toolsets for the development and design of other educational tools.

Keywords：Gender-free, knowledge sharing, software design, web-based application

2. Report Contents

2.1. Introduction

Because Taiwan has deployed national technology education from 2019 summer, that is, information education, part of the technology education, is forcedly executing in most schools except for the primary schools. However, most primary schools still utilize some ways to implicitly teach their students. Anyway, the computational thinking (CT)[1], even fundamental programing, is a common entry-level course for information education. Also, the science, technology, engineering, art and mathematics (STEAM)[2] concept was accepted by most developed countries. Also, the wave of the STEAM is continuously deploying in these regions. However, the gender distribution is abnormal in most engineering-based classrooms. Therefore, programming education becomes a challenging, related to socio-economic development, global competitiveness, and new breakthroughs in gender and ethnicity.

On basis of the above views, our research team grouped a couple researchers to discuss, analyze and discover a possible solution for promoting gender innovations in disadvantaged situations, exploring the technological and industrial policy directions for entrepreneurship, discovering the optimal way of resource allocation, assessing the key success factors, and even proposing a short, medium, and long-term benchmarking models and methods.

2.2. Research Goal

Our research goal is to try to discover the gender-free variables of our developed educational tools. Further, we might derive specific educational tool might be suitable for using by which kind of gender. Generally, every educational tool might have its own gender divergence, however, these differences might be not so obvious to be judged at once. Furthermore, our research team plans to design and setup the educational tools by the gender variables that are founded in this research.

2.3. Literature Exploring

In this section, we illustrate the following parts: female education, educational tool, and cyber-physical systems (CPS).

Frankly, there are many researches can be found for female engineering-related education, such as

[1] Wing, J. M. *(2006). Computational thinking.* Communications of the ACM*. 49(3): 33.* doi*:* 10.1145/1118178.1118215.
[2] STEAM, The Institute for Arts Integration and STEAM. (2021). URL: https://artsintegration.com/what-is-steam-education-in-k-12-schools/.

Denner, et al.[3] presented a strategy for coding student games, and summarize the results of an analysis of 108 games created by middle school females using Stagecast Creator in an after school class in 2012. Further, Pechtelidis, et al.[4] explored the possible reasons behind the uneasy relationship between women and technology in 2015. Then, Pinkard, et al.[5] suggested that their narrative-centered, blended learning program design sparks non-dominant females' interests in STEAM activities and disciplinary identification and has the potential to mediate females' sense of STEAM agency, identities and interests in 2017. In 2019, Falco's study[6] invited 88 females, 42 students were Latina and 46 were White, 40 were freshman, and 48 were sophomores attending the same high school. Further, Ahmed's brain study[7] found that young boys and girls have the same mathematics abilities.

Except for the above researches, first of all, Faulkner, et al.[8] identified aspects of the one strategy which do not fit this section of the community and conclude that digital inclusion efforts must be based on gender-aware effective targeting if they really are to include everybody in the community in 2005. However, Denner, et al.[9] cited that there is a clear need to increase females' leadership in technology. Meanwhile, their statistics show the need for interventions that can increase the interest and ability of female students to persist in computer science (CS) classes, and ultimately in computer technology-related careers.

From the positive outcomes part, Chase, et al.[10] cited that they adapt peer instruction and cooperative learning to improve student's learning of Principles of CS. Their research's improvement was more dramatic for the female students in the classes, who improved from a 53% withdraw, dead and fail (WDF; a.k.a., DFW) rate to a WDF rate of only 15%. Further, Robnett, et al.'s findings[11] suggest that positive peer connections may be a valuable resource for females and women in the STEAM pipeline in 2016.

On the contrary, the negative outcome part, Beyer, et al.[12] examined gender differences and differences in CS majors vs. non-majors in ability in quantitative areas, educational goals and interests, experience with computers, stereotypes and knowledge about CS, confidence, personality, support and encouragement, stress and financial issues, gender discrimination, and attitudes toward the academic environment in CS. They found that female CS majors had less computer confidence than did male non-majors. In 2017, Main, et al.[13] said that several initiatives and programs have been implemented to

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[3] Denner, J., Werner, L., Ortiz, E. (2012). Computer games created by middle school girls: Can they be used to measure understanding of computer science concepts? Computers & Education, 58(1): 240-249.

[4] Pechtelidis, Y., Kosma, Y., & Chronaki, A. (2015). Between a rock and a hard place: women and computer technology. Gender and Education, 27(2), 164-182.

[5] Pinkard, N., Erete, S., Martin, C. K. (2017). Digital Youth Divas: Exploring Narrative-Driven Curriculum to Spark Middle School Girls' Interest in Computational Activities. Journal of the Learning Sciences, 26(3): 477-516.

[6] Falco, L. D., Summers, J. J. (2019). Improving Career Decision Self-Efficacy and STEM Self-Efficacy in High School Girls: Evaluation of an Intervention. Journal of Career Development, 46(1): 62-76.

[7] Ahmed, S. (2019). Brain Study Finds That Young Boys And Girls Have The Same Math Abilities. Retrieved 2020, February 11, from https://www.dogonews.com/2019/12/5/brain-study-finds-that-young-boys-and-girls-have-the-same-math-abilities.

[8] Faulkner, M, Lie, M. (2007). Gender in the Information Society: Strategies of Inclusion. Gender, Technology and Development, 11(2): 157-177.

[9] Denner, J., Werner, S. B. L., Campe, S. (2005). The Girls Creating Games Program: Strategies for engaging middle school girls in information technology. Frontiers: A Journal of Women's Studies, 26(1): 90-98. DOI: 10.1353/fro.2005.0008.

[10] Chase, J., Okie, E. (1999). Combining cooperative learning and peer instruction in introductory, computer science. SIGCSE Technical Symposium on Computer Science Education, 32(1): 372-376.

[11] Robnett, R. D. (2016). Gender Bias in STEM Fields: Variation in Prevalence and Links to STEM Self-Concept. Psychology of Women Quarterly, 40(1): 65-79.

[12] Beyer, S., Rynes, K., Perraul, J., Hay, K., Haller, S. (2003). Gender differences in computer science students. SIGCSE Bull 35(1): 49-53.

[13] Main, J. B., Schimpf, C. (2017). The Underrepresentation of Women in Computing Fields: A Synthesis of Literature Using a Life Course Perspective. IEEE Transactions on Education, 60(4): 296-304.

address women's under-representation in computing fields.

No matter the outcomes' tendency, some researches disclosed the affections, such as Cadinu, et al.[14] concluded that women under stereotype threat showed a sharp decrease in performance that was most pronounced in the second half of the test and was mediated by the increase in negative thinking. In 2012, Lang's research[15] found a pattern of factors specific to information technology that encouraged some males to choose this career path and a pattern of inhibiting factors that had a stronger negative impact on young women than young men. Moakler, et al.'s findings[16] suggest that students' confidence level in their academic and mathematics abilities makes a significant difference in their initial STEAM major choice. In 2017, Alvarado, et al.[17] found significant differences between the reported behaviors and feelings of female students compared to male students: female students are less comfortable asking questions in class and interacting with their instructor, and come out of a class with lower confidence in their ability to tutor for the class, despite the fact that they perform just as well as male students.

Furthermore, some researchers provide their design for gender education, such as Wajcman[18] suggested that the contemporary focus on cultural representation and consumption, exciting and productive as it is in many respects, has contributed to the neglect of design studies. Faulkner[19] cited that feminist research on technology tends to view technology either as neutral or as determining, drawing implications for women that are either over-optimistic/-pessimistic. Also, his proposed framework by exploring various ways in which technology may be gendered, drawing in part on recent research on engineering. Milgram[20] strongly suggested when educators normalize women as engineers, mechanics, pilots, electricians, astronauts, game developers, and surgeons through repeated visual reminders, then we will see a shift similar to "Rosie the Riveter" in World War II. The "Rosie the Riveter" presents I can do it! In 2013, Shillabeer, et al.[21] proposed a number of initiatives and key success factors for closing the gender gap are presented.

In 2015, Zagami, et al.[22] concluded that the only discernable difference between initiatives to improve female participation in computing and the successful approaches in other fields such as science, has been the availability of a compulsory developmental curriculum beginning from the start of school, that may provide a scaffold that sustain female engagement over critical periods such as adolescence, when participation in computing begins to dramatically decline. Hence, a formal and compulsory curriculum is a must in our research. Meanwhile, Gabay-Egozi, et al.[23] recognized that boys and females

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[14] Cadinu, M., Maass, A., Rosabianca, A., Kiesner, J. (2005). Why Do Women Underperform Under Stereotype Threat? Evidence for the Role of Negative Thinking. Psychological Science, 16(7): 572-578.

[15] Lang, C. (2012). Sequential attrition of secondary school student interest in IT courses and careers. Information Technology & People, 25(3): 281-299.

[16] Moakler, M., & Kim, M. (2014). College Major Choice in STEM: Revisiting Confidence and Demographic Factors. The Career Development Quarterly, 62(2), 128-142.

[17] Alvarado, C., Cao, Y., Minnes, M. (2017). Gender Differences in Students' Behaviors in CS Classes throughout the CS Major. Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE '17), New York, USA, pp. 27-32.

[18] Wajcman, J. (2000). Reflections on Gender and Technology Studies: In What State is the Art? Social Studies of Science, 30(3): 447-464.

[19] Faulkner, W. (2001). The Technology Question in Feminism: A View from Feminist Technology Studies. Women's Studies International Forum, 24(1): 79–95.

[20] Milgram, D. (2011). How to Recruit Women and Girls to the Science, Technology, Engineering, and Math (STEM). International Technology and Engineering Educators Association, 71(3): 4-11.

[21] Shillabeer, A., Jackson, K. (2013). Gender imbalance in undergraduate IT programs: A Vietnamese perspective. Innovation in Teaching & Learning in Information & Computer Sciences, 12(1): 70-83.

[22] Zagami, J., Boden, M., Keane, T., Moreton, B., Schulz, K. (2015). Girls and Computing: Female participation in computing in Schools. Australian Educational Computing, 30(2).

[23] Gabay-Egozi, L., Shavit, Y., Yaish, M. (2015). Gender Differences in Fields of Study: The Role of Significant Others and Rational Choice Motivations. European Sociological Review, 31(3): 284-297.

have different educational preferences and they conceptualized gender differentiation as an outcome of both socialization processes and rational choice factors. In 2018, Spieler[24] set a focus on female teenagers, significant dependencies between whether or not the learning goal had been achieved could be seen based on the different ages of the students, the group constellation, and which teaching approach was used.

After formal education, some researchers focus on the recruit issue, such as Faulkner, et al.[25] said that particular measures are needed to recruit more women into the information, communication and technology (ICT) profession and to curb marginalization within the profession in 2007. Further, in 2009, McLoughlin[26] cited that more attention to Non-traditional Engineering Organized (NEO) students may be warranted in attempting to recruit high school women into engineering. In 2015, Bystydzienski, et al.[27] cited that career counselors and college recruiters have an important role to play in the recruitment and retention of females of color in engineering and other STEAM college majors, including facilitating support and access to appropriate programs and resources at pivotal times.

Most advanced countries have included information technology as fundamental education. Further, many technology products have been derived into education tools in the classroom while new technologies are booming. However, few researcher have paid much attention to the feeling of learner on multiple genders.

The CT is a set of problem-solving approaches that include expressing problem and solution discovery. Meanwhile, they can be executed in the computer. Also, these approaches can be spanned from basic CT for entry-level to advanced CT for professional. Further, the CT is becoming the fundamental education course for most developed countries and the programming course is one of the basic CT courses. Hence, it is required for our young students to learn most CT approaches from the Internet.

In 2019, Taiwan has started its new course guidelines for the information education field for K12 education to promote CT. That is, some selective courses for STEAM were deployed in high schools. However, CT is an abstract and implicit concept for learning to solve problems by using engineering solutions. Hence, most K12 education adapts programming courses. Also, some famous online judgers, such as ZeroJudge[28], in Taiwan for K12 students to assess their learning efficacy. Further, the Advanced Placement Computer Science (APCS)[29] examination is also a national contest for K12 students, especially for K7-K12 in Taiwan. Most colleges accept the APCS scores as entering permission for special talent channels of programming. Further, there are a couple of online judges and contests for college usage, such

[24] Spieler, B. (2018). Reinforcing Gender Equality by Analysing Female Teenagers' Performances in Coding Activities: A Lesson Learned. Proceedings of the 4th ACM Conference on Gender & IT (GenderIT '18), Heilbronn, Germany, pp. 209–219, DDOI: 10.1145/3196839.3196871.

[25] Faulkner, W., Kleif, T. (2005). One Size Does Not Fit All! Gender In/Exclusion in a Rural Community-Based ICT Initiative. Journal of Adult and Continuing Education, 11(1): 43-61.

[26] McLoughlin, L. A. (2009). Success, recruitment, and retention of academically elite women students without STEM backgrounds in US undergraduate engineering education. Engineering Studies, 1(2): 151-168.

[27] Bystydzienski, J. M., Eisenhart, M., Bruning, M. (2015). High School Is Not Too Late: Developing Girls' Interest and Engagement in Engineering Careers. Career Development Quarterly, 63(1): 88-95.

[28] Jiang, C. H. (2020). ZeroJudge, Senior High School of NKNU. https://zerojudge.tw

[29] APCS (2020). URL: https://apcs.csie.ntnu.edu.tw

as CPE[30], e-Tutor[31], etc. in Taiwan.

Furthermore, learning gaps still existed and they cannot continuously understand and learn advanced courses in case of entry-level students cannot enter the introductory course smoothly. Such a situation would affect their further learning paces. To promote the learning performance for programming, it is so important for us to develop a set of motivation-enhancing and easy-understanding education tools with well-designed assessments.

As observing to the governmental selection results for programming contests in Kaohsiung's senior high students for entering the Taiwan Olympic in Informatics (TOI)[32], we found that few female student was filtered to recommend to the TOI program, no matter then the International Olympic in Informatics (IOI)[33] . That is, female students on the CT field are relatively weaker than male students'. Hence, it is necessary to pay attention to provide some solutions to non-male students to learn the CT courses.

Because of the education tool might be software/hardware co-designed, it is necessary for our research team to find an optimal approach to refactor our selected education tool. Fortunately, in 2016, the research team in the University of California, Berkeley defines the CPS[34] as an integrated feedback system that can process calculations, networks, and physical programs in real-time. The CPS is one of the best ways to analyze and model the software/hardware co-design tasks. Meanwhile, it is wide-accepted by most researchers in the world.

Firstly, University of California, Berkeley defines CPS as an integrated feedback system that can process calculations, networks, and physical programs in real time. Therefore, we use CPS design concept to carry out the software development activities of this research. Fundamentally, most researchers will import Finite State Machine (FSM) into their CPS solution. For example, Yang[35] presented its findings in Australia on a model-oriented design approach via FSM in a distributed automation system. Later, Whitistt[36] introduced the FSM model in the America to control an automated ground transporter. In 2014, Kim[37] used FSM in Denmark to implement and verify its software device.

Hence, using FSM will be one of the core concepts in designing CPS. Finally, Lee & Seshia[38] also detailed in his second edition of the book how to use FSM to develop embedded systems with the CPS concept.

In 2019, Chaudhry, et al.[39] illustrated that CPS applications are widely used to control critical

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30 CPE (2021). URL: https://cpe.cse.nsysu.edu.tw/
31 E-Tutor, MOE, URL: https://e-tutor.itsa.org.tw/e-Tutor/
32 Taiwan Olympiad in Informatics (TOI). URL: http://toi.csie.ntnu.edu.tw
33 International Olympic in Informatics (IOI). URL: https://ioinformatics.org
34 University of California, Berkeley. (2016). Cyber-physical systems. Berkeley, CA, USA. Retrieved from http://cyberphysicalsystems.org/.
35 Yang, C. H., Vyatkin, V., Pang, C. (2013) Model-Driven Development of Control Software for Distributed Automation: A Survey and an Approach, IEEE Transactions on Systems, Man, and Cybernetics: Systems, 44(3): 292-305.
36 Whitistt, S., Sprinkle, J. (2013). Modeling Autonomous Systems, Journal of Aerospace Information Systems, 10(8): 396-413.
37 Kim, J., Kang, I., Choi, J. Y., Lee, I., Kang, S. (2014). Formal Synthesis of Application and Platform Behaviors of Embedded Software System, Software and Systems Modeling, pp. 1-21.
38 Lee, E. A. and Seshia, S. A. (2014). Introduction to embedded systems: A cyber-physical systems approach, Edition 2. Retrieved from http://LeeSeshia.org.
39 Chaudhry, N., Yousaf, M. M., Khan, M. T. (2019). Security assessment of data management systems for cyber physical system applications. Journal of Software-Evolution and Process, e2241, DOI: 10.1002/smr.2241.

infrastructure of various application domains, for example, software[40,41,42], hardware/software co-design[43,44], big data[45,46], security[47,48], network[49], vehicle[50,51], industry[52,53], healthcare[54,55], etc. These applications usually collect input data from sensors, estimate current state of the system, and make decisions based on the estimation to automatically control the subsequent processes.

From the software view of points, In 2016, Jiang, et al.[56] said that software and middleware is the soul of the CPS. Then, Garcia-Valls, et al.[57] and Yu, et al.[58] cited such comments. Further, Jiang, et al.[59] cited that the CPS is an emerging area that cannot work efficiently without proper software handling of the data and business logic. Hence, our adaption has to take care both of the logic and big data views.

From the data view of points, for example, in 2017, Song, et al.[60] proposed a big-data-driven approach, topic-oriented learning assistance (TOLA), for online learning evolution is proposed to discover students' learning pattern and guide courses improvement. Luo, et al.[61] proposed their model and application for big data analytics and proposed a comprehensive framework for integrating big data analytics into CPS solution. Therefore, we understand that the CPS is a good approach for manage big data for our research.

We believe that our proposal with the empirical study based on the CPS theory could successfully promote toolsets development for young female students that interest on the engineering field. On basis of

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[40] Jiang, Y., Chen, C. L. P., Duan, J. (2016). A new practice-driven approach to develop software in a cyber-physical system environment. Enterprise Information Systems, 10(2): 211-227.

[41] Garcia-Valls, M., Bellavista, P., Gokhale, A. (2017). Reliable software technologies and communication middleware: A perspective and evolution directions for cyber-physical system, mobility, and cloud computing. Future Generation Computer Systems-The International Journal of eScience, 71: 171-176.

[42] Yu, H., Qi, H., Li, K. (2019). A powerful software-defined cyber-physical system to expand CPS adoption. Software-Practice & Experience, DOI: doi.org/10.1002/spe.2728.

[43] Sztipanovits, J., Bapty, T., & Koutsoukos, X. (2018). Model and Tool Integration Platforms for Cyber-Physical System Design. Proceedings of the IEEE, 106(9): 1501-1526.

[44] Lv, C., Hu, X. Sangiovanni-Vincentelli, A. (2019). Driving-Style-Based Codesign Optimization of an Automated Electric Vehicle: A Cyber-Physical System Approach. IEEE Transactions on Industrial Electronics, 66(4): 2965-2975.

[45] Song, J., Zhang, Y., Duan, K. (2017). TOLA: Topic-oriented learning assistance based on cyber-physical system and big data. Future Generation Computer Systems-The International Journal of eScience, 75: 200-205.

[46] Luo, S., Liu, H., Qi, E. (2019). Big data analytics - enabled cyber-physical system: model and applications. Industrial Management & Data Systems, 119(5): 1072-1088.

[47] Vellaithurai, C. B., Biswas, S. S., Srivastava, A. K. (2017). Development and Application of a Real-Time Test Bed for Cyber-Physical System. IEEE Systems Journal, 11(4): 2192-2203.

[48] Chaudhry, N., Yousaf, M. M., Khan, M. T. (2019). Security assessment of data management systems for cyber physical system applications. Journal of Software-Evolution and Process, e2241, DOI: 10.1002/smr.2241.

[49] Park, S. O., Xiao, B., Leung, V. (2013). Advanced technologies and applications for Highly-Reliable Cyber Physical System (HRCPS). Journal of Supercomputing, 66(1): 1-3.

[50] Nawa, K., Chandrasiri, N. P., Yanagihara, T. (2013). Cyber physical system for vehicle application. Transactions of the Institute of Measurement and Control, 36(7): 898-905.

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[61] Luo, S., Liu, H., Qi, E. (2019). Big data analytics - enabled cyber-physical system: model and applications. Industrial Management & Data Systems, 119(5): 1072-1088.

the above explanation, therefore, we proposed the myKLA and myKLA2 toolsets. After several gender-free assessments, our research team adapts CPS theory to refactor our selected toolsets.

2.4. Methodology

In the era of advanced technology, many things are gradually replaced by technology. People have long been accustomed to the virtual world created by technology, which is even inseparable from your and my life. More and more virtual influencers are born because of this, but due to the cost of sensors is too high, the application of virtual influencers cannot be popularized.

2.4.1. System Design

In the era of advanced technology, many things are gradually replaced by technology. People have long been accustomed to the virtual world created by technology, which is even inseparable from your and my life. More and more virtual influencers are born because of this, but due to the cost of sensors is too high, the application of virtual influencers cannot be popularized.

On the other hand, the goal of the myKLA2 is used for detecting, editing, and playing the detected gestures. It includes three parts: (1) Detector web page is to detect user gestures, to display user gestures online, to reflect to the avatar gestures simultaneously, and to record user gestures in a JSON file; (2) Editor web page is used to edit user gestures from a JSON file, to concatenate recorded JSON files, to attach sound files, to provide a set of play functions; and (3) Player web page is utilized for uploading a recorded JSON file, playing a JSON file with big message notifications, detecting user gestures online, assessing whether user gestures are similar to the defined gestures in the JSON file, and giving an evaluation result for user reference.

Note that our myKLA2 application combines the detection of face, eye, and body with 3D virtual character scenes, and creates and records virtual character movements through cameras. That is, through this application, users can edit and play the related body movements and voice of virtual characters more easily. Further, users can choose the part of the body to be detected, and the system replaces the sensors and related computational components. Therefore, through the pictures captured by ordinary cameras, the rotation angles of each part of the body are calculated and various actions can be rendered in real time corresponding to the virtual characters.

Our developed tools are implemented by using well-known international standards such as HTML5, CSS3 and jQuery. The JavaScript is utilized for system programming. Meanwhile, a remote MySQL database stores all required data at Ubuntu v22.04 server. Also, we uses TensorFlow and MediaPipe models to implement face, eye, and body detections. Meanwhile, our research team developed custom JSON files for viewing and detecting recorded or edited files, and further uses the data to display corresponding actions on avatars, and can also record and edit.

2.4.2. Multipoint Detection and Real-time Computation

To maintain the smooth presentation of the recorded animations, our system is designed to execute an image recognition interactive loop every sixtieth of a second. As shown in Figure 3 below, in one cycle, the camera captures and transmits head, eye, limb, and body motion images to the front-end image recognizer to detect the coordinate position of the part. Afterward, the back-end server receives the detection result and performs gesture calculation. After the computation is completed, the results of each part are sent back to the front-end for presentation in an asynchronous manner. Also, we avoid delaying avatar animations by performing rendering and computations on the web page at the same time.

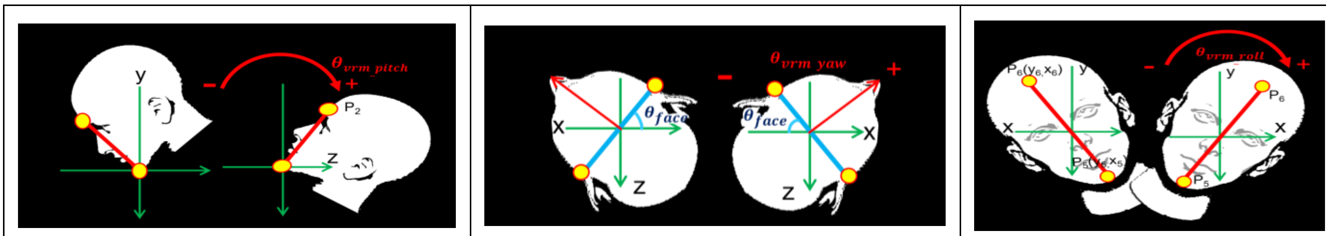
2.4.3. Computation of Head Pose

We try to identify the head position of avatar. According to Yuan and Vakunov's research suggestion[62], both MediaPipe and TensorFlow provide head detection, but because the former has a better detection effect, we use MediaPipe for head image recognition. Then, we have to calculate the rotation angle of the head. Our system divides the rotation direction calculation of the virtual character head into three directions: pitch, yaw, and roll.

First of all, we developed the pitch angle. The head pitch angle, θ_{aPitch}, in Figure 1(a) represents the required rotation angle of the head of the avatar on the x-axis. To obtain this angle, the chin and forehead identified by the image module were projected onto the yz plane perpendicular to the x-axis, as indicated by P1 and P2. Calculating the slope m_{pitch} on this plane through the straight line formed by these two points (P1, P2). Next, the magnitude of $|\theta_{aPitch}|$ is calculated by using the slope of the arctangent whose corresponding field is $\left[-\frac{\pi}{2},\frac{\pi}{2}\right]$. However, the positive and negative rules of the head pitch rotation direction of the avatar are different from the recognition kit. Therefore, when using the avatar kit, its rotation angle should be the additive inverse of $\tan^{-1}(m_{pitch})$. The following formula is then derived as below.

$$\theta_{aPitch} = -\tan^{-1}\left(m_{pitch}\right) = -\tan^{-1}\left(\frac{y_2-y_1}{z_2-z_1}\right) \quad (1)$$

[62] Yuan, A., & Vakunov, A. (2020, March 9). Face and Hand Tracking in the Browser with MediaPipe and TensorFlow. Js. TensorFlow Blog. https://ppt.cc/fmVqjx



(a)	(b)	(c)

Figure 1. Head pose computations: (a) pitch, (b) yaw, and (c) roll

Secondly, the head yaw angle, θ_{aYaw}, in Figure 1(b) represents the required rotation angle of the head of the avatar on the y-axis. The angle was calculated based on the rotation direction of the nasal cavity center-nose tip on the xz plane. However, due to the small area of the nose, it is not easy to accurately detect the distance between the two. Therefore, in this study, the yaw angle is reversed by the line segment that is close to the vertical. That is, the line segment is composed of the left cheek and the right cheek. After such an approach, the results of identifying the left and right cheeks are projected to the xz plane, which is convenient for calculation on this plane to form the $\overline{P_3P_4}$. Next, we calculate the arctangent of m_{yaw}, i.e., the slope of $\overline{P_3P_4}$ to derive θ_{face}. According to the complementary angle theorem, θ_{face} and the required rotation yaw angle θ_{aYaw} of the character's head are the same numerical angle. Therefore, the following formula can be derived as follows

$$\theta_{aYaw} = \theta_{face} = -\tan^{-1}(m_{yaw}) = \tan^{-1}(\frac{z_3-z_4}{x_3-x_4}) \quad (2)$$

Thirdly, the head roll angle θ_{aRoll} in Figure 1(c) represents the required rotation angle of the head of the avatar on the z-axis. Compared with the yaw angle, it is similar to the angle calculation method of the head pitch direction. Both of them use the chin and forehead to calculate the angle. Therefore, we project two points to the yx plane, as indicated by P5 and P6, and then obtain the head roll angle through the arctangent ($\overline{P_5P_6}$) slope method, that is, $\tan^{-1}(m_{roll})$. After that, since it is known that the positive and negative rules of the head roll rotation direction of the avatar are opposite to those of the identification kit, it is deduced that θ_{aRoll} should be the opposite number of $\tan^{-1}(m_{roll})$, as follows:

$$\theta_{aRoll} = -\tan^{-1}(m_{roll}) = \tan^{-1}(\frac{x_6-x_5}{y_6-6_5}) \quad (3)$$

2.4.4. Computation of Eye Pose

Then, we try to identify the eye position. Since MediaPipe does not provide pupil detection in JavaScript package, so we use TensorFlow to perform eye image recognition, including left and right eye and pupil detection[63].

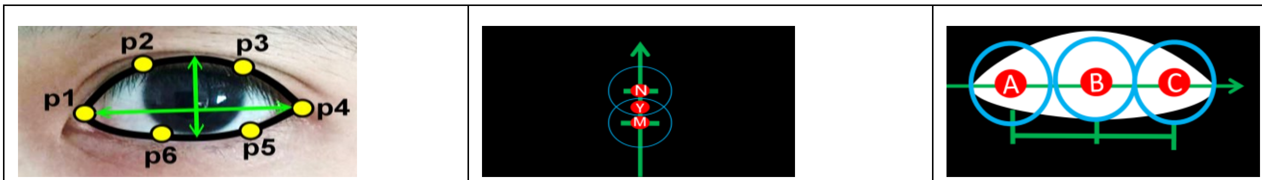
At first, we compute the degree of eye-opening and closing. That is, our application controls the

[63] Yuan, A., & Vakunov, A. (2020, March 9). Face and Hand Tracking in the Browser with MediaPipe and TensorFlow. Js. TensorFlow Blog. https://ppt.cc/fmVqjx

blinking degree weight value of the avatar to adjust its opening and closing degree state. The value range of the blink weight degree is $[0, 1]$, and the value from small to large indicates that the eyes are fully opened to closed. According to the research of Soukupová and Čech[64] in 2016, the eye-opening and eye-closing degree can be known by using the Eye Aspect Ratio (EAR). The EAR calculation method is to measure the height through p2, p3, p5, and p6 in Figure 2(a), and p2 and p4 are used to measure the width of the eye, and the formula for the aspect ratio of the eye is calculated as shown in equation (4). The range of EAR from closed to fully open is approximately $[0.05, 0.4]$. It can be seen from the above that EAR and avatar blink degree, $Degree_{a\_blink}$, are completely negatively correlated, so the two have a linear functional relationship. When the EAR value increases by 1, the avatar blink degree will decrease by 0.35, and then the following formula can be calculated.

$$\text{EAR} = \frac{|p_2 - p_6| + |p_3 - p_5|}{2|p_1 - p_4|} \tag{4}$$

$$Degree_{a\_blink} = \frac{0.4 - EAR}{0.35} \tag{5}$$



(a)	(b)	(c)

Figure 2. Eye pose computations: (a) blink, (b) move vertically, and (c) move horizontally

Then, we calculate the position of pupil movement. In this study, the avatar's pupil position is moved by adjusting the sight line of the avatar, so we convert the detection results of eye and pupil position into the relative coordinates of the avatar and its gaze target. It is mainly divided into two directions to move, one is up and down, and the other is left and right.

Firstly, we try to compute the left pupil moving vertically. For the detection and calculation of the upper and lower position of the avatar's pupil, we use the number line in Figure 2(b) and the ratio unit conversion for calculation. It shows the projection of the eye position on the y-axis. Point P_m is the center of the eye, point P_u is about the uppermost point that the center of the pupil can reach, and point P_y represents the detection result of the center of the pupil. To calculate the positions of the P_m and P_u points, we assume the pupil is a circle with radius R_p. Hence, we can try to deduce the possible $P_{u'}$ by calculating. measure the length of the upper half pupil and then moved the midpoint of the upper eyelid (P_{mu}) down by this length, and this point was used as the $P_{u'}$. Then, we treat P_m as the origin of the number line, $\overline{P_m P_{u'}}$ as a unit length, and above as the positive direction to form a number line. Finally, according to the ratio of $\overline{P_m P_y}$ and $\overline{P_m P_{u'}}$, the relative coordinate value $P_{y'}$ of the P_y on this number line can be calculated, that is, the P_y coordinate value of the target the avatar needs to focus on. Table 1

[64] Soukupová, T., & Čech, J. (2016, February). Real-Time Eye Blink Detection using Facial Landmarks. In 21st computer vision winter workshop, Rimske Toplice, Slovenia.

shows the algorithm to compute avatar-related position for pupil moving vertically.

Table 1. Compute avatar-related position for pupil moving vertically

Definition P_{mu} = midpoint of the upper eyelid P_{ml} = midpoint of the lower eyelid P_m = center point of the eye P_u = center point of the pupil that is uppermost reachable $P_{u'}$ = center point of the pupil that is adjusted for the upper eyelid R_p = radius of the pupil P_y = center point of the pupil that is detected $P_{y'}$ = center point of the pupil for avatar # Calculation $P_m = \frac{P_{mu}+P_{ml}}{2}$ # get the center point of the eye $R_p = \|P_m - P_u\|$ # radius of pupil $P_{u'} = P_{mu} - R_p$ # adjust P_u $P_{y'} = \frac{\overline{P_m P_y}}{\overline{P_m P_{u'}}}$ # map to avatar's $P_{y'}$

Secondly, we try to compute the left pupil moving horizontally. For the calculation of the left and right position of the avatar's pupil, take the left eye detection as an example. This study uses the number line formed by the three points, such as P_l, P_m, and P_r in Figure 2(c) to perform operations. The projection of the eye position on the x-axis. Point P_l is the leftmost point that can be reached by the center of the detected pupil, point P_r is the rightmost point that the center of the pupil can reach, and point P_m is both midpoint. To find the coordinate position of P_l, the system moves the left boundary point of the eye frame to the right by the left half pupil length, which is the position of point $P_{l'}$. Similarily, we can calculate $P_{r'}$. Finally, this study takes point P_m as the origin, $\overline{P_{l'}P_m}$ is a unit length, and takes the right side as the positive direction to form a number line. By converting the x-coordinate point P_x of the result of detecting the center of the pupil into the relative value $P_{x'}$ of the point on the number line, it is the x-coordinate value of the target the avatar needs to look at. Then we use the ratio calculation to convert the coordinates. It is known that $\overline{P_{l'}P_{r'}}$ is two units of length, and after measuring and deriving $\overline{P_{l'}P_x}$, the ratio between the two can be obtained. The number of length units occupied by $\overline{P_{l'}P_x}$ in the number line, and then deduce the value of $P_{x'}$. The algorithm for computing avatar-related position for pupil moving horizontally is shown in Table 2.

Table 2. Compute avatar-related position for pupil moving horizontally

Definition
P_{el} = leftmost point of the eye
P_{er} = righmost point of the eye
P_m = center point of the eye
P_l = leftmost point of the pupil
P_r = rightmost point of the pupil
R_{pl} = left radius of the pupil
R_{pr} = right radius of the pupil
$P_{l'}$ = leftmost point of the pupil that is adjusted
$P_{r'}$ = rightmost point of the pupil that is adjusted
P_x = center point of the pupil that is detected
$P_{x'}$ = center point of the pupil for avatar

Calculation
$R_{pl} = |P_m - P_l|$ # left radius of the pupil
$R_{pr} = |P_m - P_r|$ # right radius of the pupil
$P_{l'} = P_{el} - R_{pl}$ # get adjusted leftmost point of the eye
$P_{r'} = P_{er} + R_{pr}$ # get adjusted rightmost point of the eye
$P_{x'} = 2\frac{\overline{P_{l'}P_x}}{\overline{P_{l'}P_{r'}}} - 1$ # map to avatar's $P_{x'}$

Note that the pupil is not a perfect circle, hence we compute both the left and right radii at the above algorithm. Meanwhile, we capture both pupils one by one, that is, first detect the right pupil and then detect the left pupil. Then, we calculate and use the average value of both pupils. If one of them is disabled, we directly use the available pupil.

2.4.5. System Diagram

The system diagram for myKLA and myKLA2 are shown in Figure 3 and 4, respectively. Note that the client side is flexible and can be browsed at any heterogeneous operating systems. That is, it could be any browser that support HTML5 and CSS3 under any popular operating systems, such as Windows, Linux, iOS and even mobile devices.

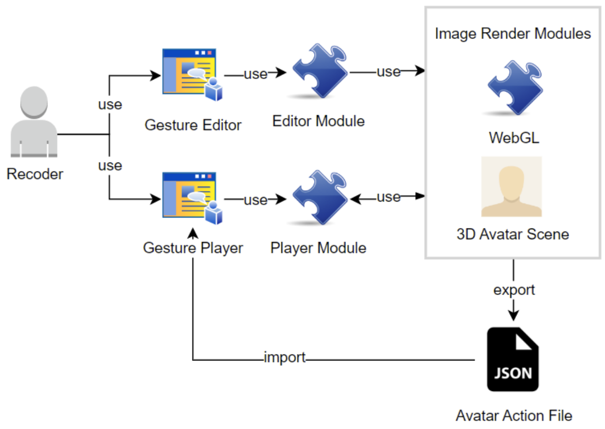


Figure 3. System diagram for myKLA

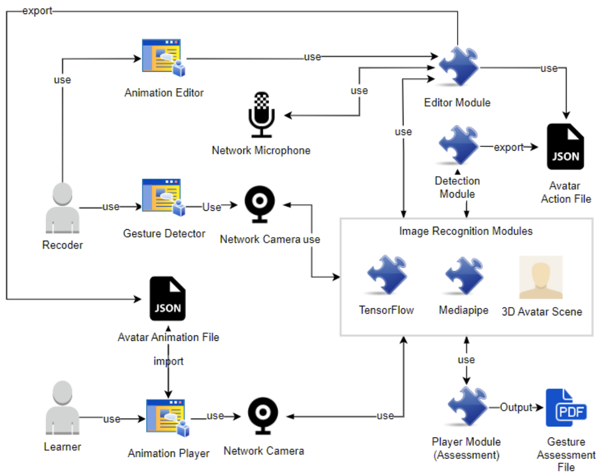


Figure 4. System diagram for myKLA2

Inside the myKLA2, we utilized Three.js library to create a three-dimensional scene and imported the virtual character model. Then, the system forwarded the captured image from the camera to the image recognition modules including at least the TensorFlow Face Landmarks Detection and MediaPipe Holistic kits for object recognition. Therefore, a real-time multi-point computation is performed through the pose calculation module established by the team on the back-end Node.js server. The final return result presents a 3D interactive screen and stores character action data.

2.5. Outcomes and Discussion

Our research team spent at least two years designing, developing, implementing, and refactoring the myKLA toolsets. There are at least two major versions and we named them myKLA and myKLA2. The first version, myKLA is on production on July 4, 2021, and subsequently, the myKLA2 is on serving on June 23, 2022. Up to now, the myKLA2 is fixed its version on September 27, 2022, and another branch was forked from myKLA2 and named myKLA3 for further revision. The following subsection illustrates the web-based myKLA and myKLA2 toolsets.

2.5.1. User Interface: myKLA

In 2018, our research team aroused a question about gender fitting. Then, we tried to utilize a three-dimensional model to replace the required actors in our educational tools. However, we not only want to define, design, and implement our actors once, but also adopt similar actors in all of the educational tools that we have implemented. After a couple of years of techniques collection, skill training, prototype development, method adoption, and process verification. We started to develop a web-based educational tool set, myKLA, to provide an environment that let instructors can design and reconfigure the required actor for their educational tool usage. Meanwhile, such a tool set can replace the actor for any kind of gender to fit the favor of students.

Generally, at least three male college students attended our research team and acted as part-time programmers to implement the myKLA web-based application in April 2021. The first prototype is constructed in June 2021. In the meantime, three female college students attended the same team in our laboratory, provided many comments for improving the design, increased a more female atmosphere, and prepared to revise the next version. For example, Figure 5 shows the screen snapshot for the home page of our proposed myKLA educational tool set and it is designed and beautified by one of the female programmers.

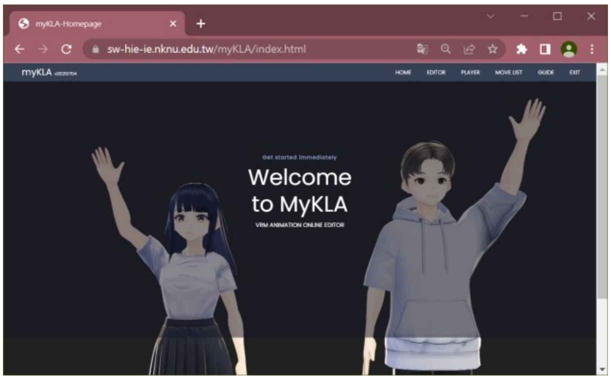


Figure 5. myKLA educational tool set

There are two major functions, such as editor and player, in the myKLA.   As their name said, the former is used for editing the detailed actions for specific actors and the latter one can perform the predefined actions for the specific actor.

First of all, we illustrate the editor features. A web page is divided into two panels. The left panel located two 3D models, one female stands at the left, and another male stands at the right side. The right panel shows two sections. The upper Edit section is used for selecting and defining the action time interval for specific actions.

Inside the Edit section, there are five drop-down lists including part, group, side, action, and gender from left to right as well as a sequential identifier for assigning specific actions. At last, every action accompanies a time interval scroll bar to define the action's playing duration. Note that the default time interval for action play is limited to 60 seconds and we can adjust it for whatever we like.

The part drop-down list includes face, limb, body, and location. Further, the group drop-down list is shown by a distinct part selection. For example, it shows three items, such as arm, finger, and leg, after we select a limb item in the part list. All of the actions are listed at Table 3 and we also place it named 'Move List' at the menu bar.

Table 3. Move list for myKLA

Part	Group	Side	Actions
Face	Emotion	N/A	Fun, angry, sorrow, joy, surprised and blink
	Mouth	N/A	A, e, i, o, u
Limb	Arm	both, left, right	Hang, swing, lift, hold, wave, stroke, shrug, salute, arm-heart, raise and at-ease
	Finger	both, left, right	fist, spread and thumb-up
	Leg	both, left, right	Walk, left-knee, raise-leg, and skretch
Body	Waist	N/A	Bow

After defining a specific action, such an action definition will be shown in the lower Actions section as Figure 6 shown. For example, we can define the boy model to hand his left arm for 3 seconds, swing his left arm for the next 3 seconds, and then lift his left arm for later 3 seconds, and so on. Meanwhile, we can define the girl model to lift her right leg in walking style for 3 seconds, lift her right knee for the next 3 seconds, and then raise her right leg for another 3 seconds, etc. That is, all of the actions inside the move list can be predefined in this editor.

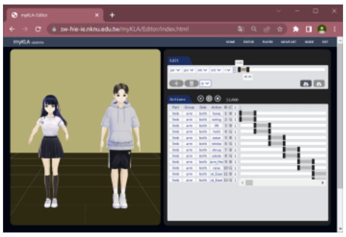
Figure 6. Screen snapshot for myKLA editor

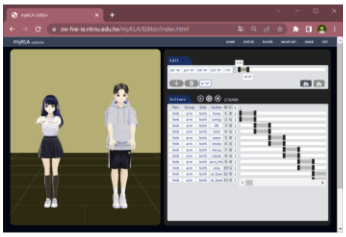
Also, we provide at least five functions to manage the editing process. These functions include adding an action with a plus sign, removing an action with a trash can, sequential identifier selection by a drop-down list, uploading an external predefined action file with a cloud upload sign as well as downloading currently defined actions and saving as a JSON file format. Table 4 shows the action file syntax of myKLA.

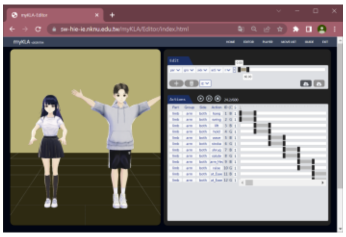
Table 4. Action file syntax of myKLA

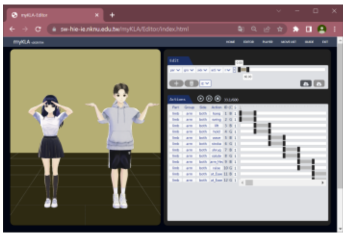
```
{
        "actionDefined":    [actionSingle, …],
        "timeline":    [timelineSingle, …],
        "moveEndTime": []
}

actionSingle := [
        id: string,
        partNo: number,
        groupNo: number,
        sideNo: number,
        actionNo: number,
        genderNo: number,
        part: string,
        group: string,
        side: string,
        action: string,
        gender: string]
```

Subsequently, the player can be used to perform the actions that are predefined JSON files. Figure 7 shows most of the gestures that can be edited by myKLA editor. For example, subfigures (a1)~(a6) demonstrate the actions of both limbs including hanging arms, swinging arms, lifting arms, holding arms, waving arms, stroking arms, shrugging, saluting, heart shape with arms, raising arms, and arms at ease. Of course, the two models demonstrated different actions. Further, subfigures (b1)~(b2) show that the gestures can be controlled for the left and right limbs by user definition.


(a1)


(a2)


(a3)


(a4)

(a5) (a6) (b1) (b2)

Figure 7. Screen snapshot for myKLA player

2.5.2. User Interface: myKLA2

In this subsection, we tried to show the upgraded version of myKLA that was developed and beautified by three female college students. Figure 8 shows the home page of myKLA2. As the menu is shown, the myKLA2 provides three features: detector, editor, and player. Both editor and player inherited from the myKLA. However, we provide much stability and performance in the myKLA2 version.

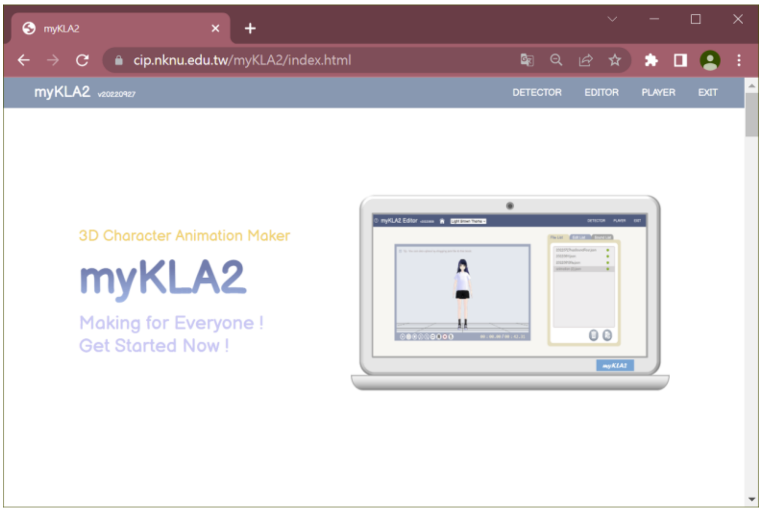
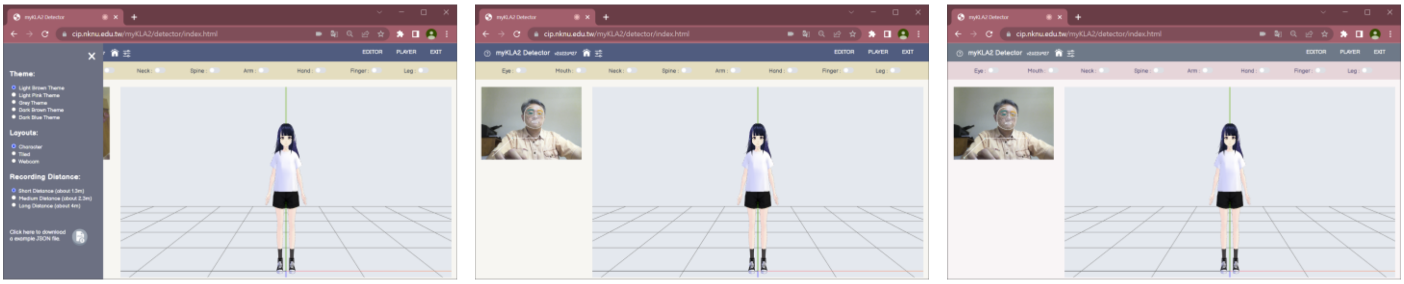
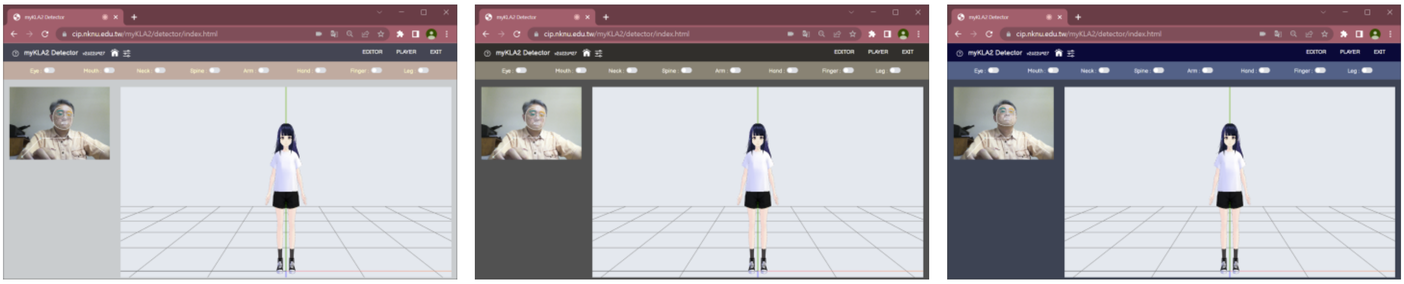


Figure 8. Screen snapshot for myKLA2 home page

The myKLA2 refactored codes for the user interface and provided more five themes for user selection, such as light brown, light pink, gray, dark brown, and dark blue. For example, Figure 9 shows the decoder page of myKLA2 with a left-floating menu to provide a radio button to select one of the above five color themes and show all subfigures with a character-oriented layout. Of course, we can provide more themes for users, however, limited choices are shown for presenting our gender-free design approach. Further, the color themes of the myKLA2 are planned to be reconfigured by a color palette and let users pick their favorite colors.



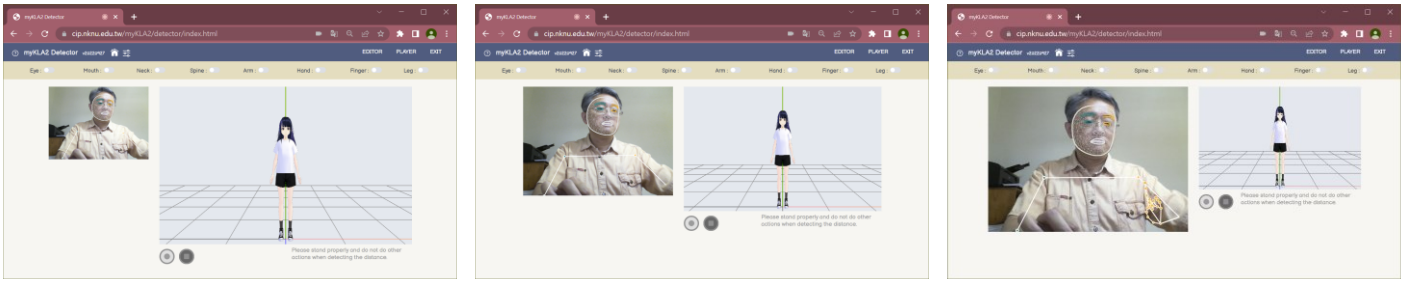
(1) left-floating menu (2) light brown theme (3) light pink theme



(4) gray theme (5) dark brown theme (6) dark blue theme

Figure 9. Screen snapshot for myKLA2 decoder: theme

For leveraging the view of the character and webcam panels, we provide at least three layouts, character, titled, and webcam, for users. Figure 10 illustrates these three layouts. Furthermore, such a layout might be fixed for user usage. Therefore, we plan to reconfigure the web page with a movable separate frame in the next version. We believe that such a design would be more acceptable for most users. As the programmer comments said, the more choices of features, the more affordable for users.

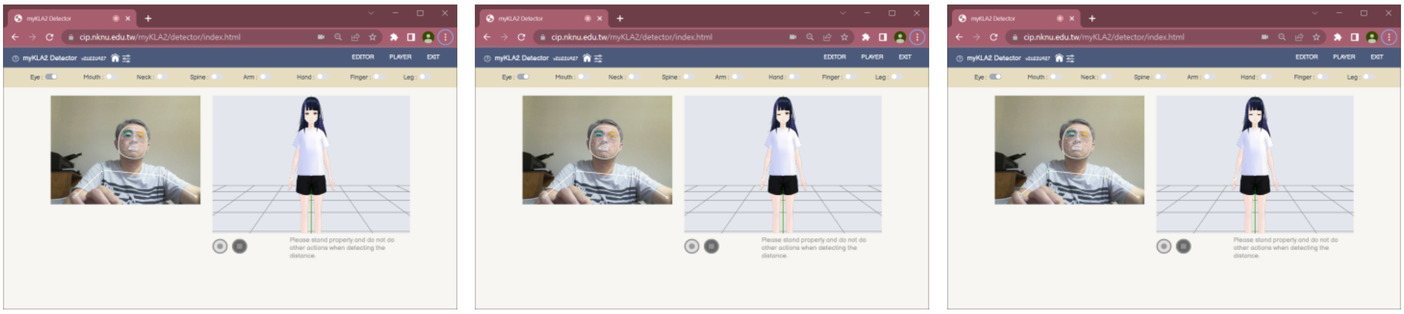


(1) character layout (2) titled layout (3) webcam layout

Figure 10. Screen snapshot for myKLA2 decoder: layout

Also, we provide a recording distance of the user's cam with three choices, such as short-distance (approximate 1.3 meters), medium-distance (approximate 2.3 meters), and long-distance (approximate 4 meters). Basically, such a design aims to optimize gesture-capturing algorithmic computation. For example, we can choose the short-distance option for capturing the face and gesture of the upper side of the body. On the other hand, we can select the long-distance choice for capturing the whole body gestures. Some of the parameters have to be adjusted for further computation. Therefore, such options cannot let users resize their vision inside the cam display panel.

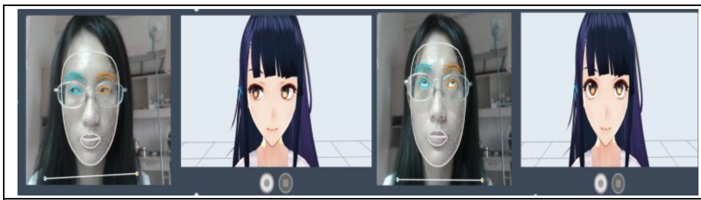
This detector can online capture user gestures by user’s cam, show the gesture on the web page, and reflect the gesture to the 3D character. Also, we provide eight switches, such as eye, mouth, neck, spine, arm, hand, finger, and leg, for the user to select their favorite parts of the body for further recognition. Figure 11 shows myKLA2 detector for recognizing eye style. Sometimes due to the user's muscle force or individual differences, the gap between the aspect ratio of the eye and the average value of the system is large. Hence, the errors occur and cannot be presented well.



(1) eyes opened (2) eye blinking (3) eyes closed

Figure 11. Screen snapshot for myKLA2 detector: recognize eye style

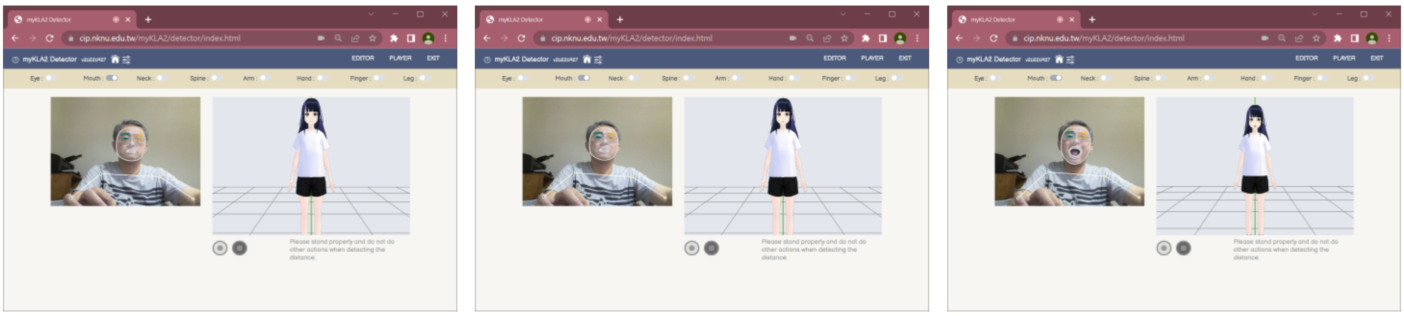
In addition, it can be seen from Figure 12 that the rendering result of pupil movement is good. However, its detection is relatively unstable, and sometimes it is difficult to detect due to the small area of the eyes and pupils, and thus the image recognition might get wrong response.



(a) (b)

Figure 12. Screen snapshot for myKLA2 detector: recognize pupil moving (a) pupil move right and (b) pupil move upward

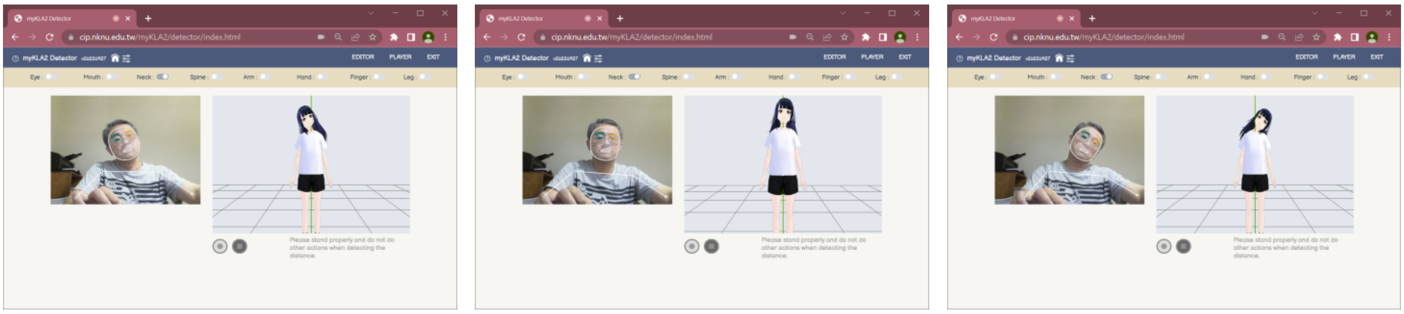
Further, Figure 13 shows the mouth action with closed, slightly open, and open, respectively.



(1) mouth closed (2) mouth slightly open (3) mouth open

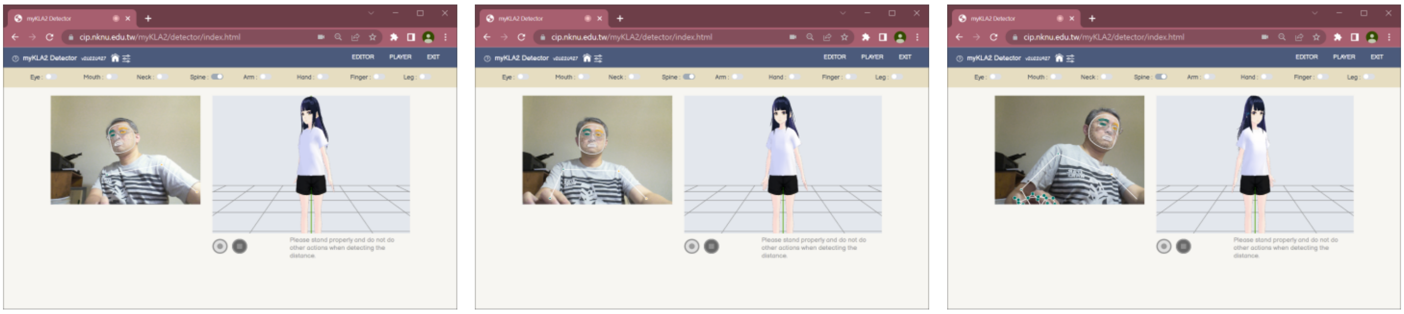
Figure 13. Screen snapshot for myKLA2 detector: recognize mouth action

Also, Figure 14, 15, and 16 illustrates the recognition outcomes for neck position, spine position, and arm actions, respectively.



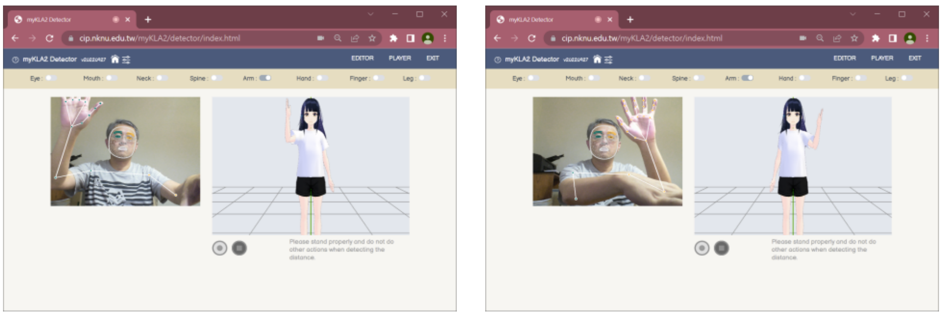
(1) head tilted to the left (2) head centered (3) head tilted to the right

Figure 14. Screen snapshot for myKLA2 detector: recognize neck position



(1) spinal rotation to the left (2) spinal alignment (3) spinal rotation to the right

Figure 15. Screen snapshot for myKLA2 detector: recognize spine position



(1) left arm (2) right arm

Figure 16. Screen snapshot for myKLA2 detector: recognize arms

Also, we provide tips for users to quickly refer to the correct operations. Meanwhile, the control panel of the model shows nine controls including play, pause, stop, move backward for five seconds, move forward for five seconds, loop play, mark, record, and turn on/off the microphone. This panel also provides the current time counts and total time length for all actions. At last, Table 5 shows the action file syntax of myKLA2.

Table 5. Action file syntax of myKLA2

```
{
  animation: Record data of part of body [
    rotateAngle,
    actionFlag,
    actionName,
    buttPos,
    animTime,
    editTime]
  voice: format of voice in text mode,
  userPositionZ: Distance between camera and face
}
```

2.5.3. Problem Solving

In recent years, due to the impact and convenience of the epidemic, many people have begun to use online environments and systems, but this has also reduced the opportunity to communicate with others. If virtual characters are used in the system, it can not only achieve the effect of companionship, increase interactivity, but also relatively improve the user's willingness to use.

The user can select the part to be detected, identify the part from the captured image of the camera, calculate the rotation angle of the head, the degree of eye opening and closing, and the position of the pupil movement, and map the data to each part of the avatar to realize various actions in real time.

2.5.4. Performance Metrics: myKLA

After the implementation of the myKLA and the myKLA2, our research team proceeded with system metrics to try to promote the performance of execution. Both systems are implemented and allocated all of our computational components to the distinct Node.js servers inside two different remote VMware virtual machines under HP ProLiant DL360 Gen9 with two Intel Xeon CPU E5-2620 v4 2.10GHz in eight cores per CPU, 32GB memory, and 500GB hard disk.

Firstly, Table 6 shows the performance metrics of myKLA and which was measured on September 2nd, 2022. The client environment of our metrics is Intel Core i7-8565U with 16GB memory, Intel UHD Graphics 620 video card, and Google Chrome v106.0.5249.119 (64-bit). Both editor and player pages show boy and girl avatars with file sizes of approximately 10.0 MB and 14.2 MB, respectively. On the editor web page, the average time expenses of our codes and the third-party libraries take 5,858 ms (213 KB) and 1.107 ms (2,591 KB), respectively. It makes sense that our codes call several libraries and wait for completion, however, our codes have a lot of optimization opportunities. Also, it shows that loading the male avatar (10.312 MB) and female avatar (14.662 MB) take approximately 4,488 ms and 4,266 ms, respectively.

Table 6. Performance metrics of myKLA

Features	Activities	File Size (KB)	Average Time Expense (ms)
Editor	Initialization: load our codes	213	5,858
	Initialization: load the third-party libraries	2,591	4,618
	Initialization: load boy avatar	10,312	4,488
	Initialization: load girl avatar	14,662	4,266
Player	Initialization: load our codes	136	1.107
	Initialization: load the third-party libraries	2,267	779
	Initialization: load boy avatar	10,312	4,176
	Initialization: load girl avatar	14,662	3,607
	If the user tries to use one JSON file	13	12

In the player web page, the average time expenses of our codes and the third-party libraries take 1.107 ms (136 MB) and 779 ms (2,267 KB), respectively. Also, our codes need further optimization. System loads the same pair of the avatars takes approximately 4,176 ms and 3,607 ms, respectively. Alternatively, the JSON file size is so small, 13.1 KB, that its average time expense, 12 ms, is negligible.

2.5.5. Performance Metrics: myKLA2

On the other hand, Table 7 shows the performance metrics of myKLA2 and which was measured on September 2nd, 2022. The client environment of our metrics is Intel Core i7-118000H with 16GB memory, Nvidia GeForce RTX 3050 video card, and Google Chrome v106.0.5249.119 (64-bit). Similarly, every web page downloads required libraries and resources for initialization. For example, the system will try to download one 3D avatar, default shown as the girl-1, and related computational components after clicking the detector option in the system menu.

Table 7. Performance metrics of myKLA2

Features	Activities	File Size (KB)	Average Time Expense (ms)
Detector	Initialization: load our codes	378	28,280
	Initialization: load the third-party libraries	34,788	29,797
	Initialization: 1 avatar	17,305.6	724
Editor	Initialization: load our codes	1,160	33,122
	Initialization: load the third-party libraries	2,584	3,111
	Initialization: 1 avatar	17,305.6	859

Player	Initialization: load our codes	469	39.553
	Initialization: load the third-party libraries	43,895	32,896
	Initialization: 4 avatars	55,705.6	39,718
	If tries to use one JSON file	3,519.0	1
	If tries to use 12 JSON files	35,100.0	3

Fundamentally, the sizes of the 3D avatar files for boy-1, boy-2, girl-1, and girl-2, are approximately 10.0 MB, 13.3 MB, 16.9 MB, and 14.2 MB, respectively. Of course, the file size of the 3D avatar is one of the key points to affect the performance during the initialization phase of every web page. Originally, we choose the boy-1 avatar with the smallest file size as our default one, however, we choose the girl-1 as our default avatar for gender-free consideration. Actually, user can freely select any avatar.

On the detector web page, the average time expenses of our codes and the third-party libraries take 28,280 ms (378 KB) and 29,797 ms (34,788 KB), respectively. Also, it shows that loading the female avatar (17.306 MB) takes approximately 724 ms. Then, on the editor web page, the average time expenses of our codes and the third-party libraries take 33,122 ms (1,160 KB) and 3,111 ms (2,584 KB), respectively. Also, the average time expense of the same female avatar takes approximately 859 ms. At last, on the player web page, the average time expenses of our codes and the third-party libraries take 39,553 ms (469 KB) and 32,896 ms (43,895 KB), respectively. Also, the total loading time of four avatars (55.706 MB) takes approximately 39,718 ms. Similarly, the average time expense for loading one JSON file (3.519 MB) and 12 JSON files (35.100 MB) take approximately 1 ms and 3 ms, respectively, of course, these two time expenses are small and can be ignore for their effect.

2.5.6. Future Outlook

In the current era of the prevalence of virtual environments, we hope users can use the myKLA and myKLA2 to establish virtual character action files, so that virtual characters assist in the role of companionship. Meanwhile, learners can not only increase their motivation when facing various training challenges, such as rehabilitation, etc., but also to avoid feeling lonely or learned helplessness.

The color themes of the myKLA2 are planned to be reconfigured by a color palette and let users pick their favorite colors. Further, the system performance plans to be optimized by adopting advanced techniques, such as delay importing modules, etc.

In addition, with the gradual maturity of virtual technology, the use of virtual characters has become more and more extensive, which will be a trend in the near future. Furthermore, it is expected that it can be combined with other fields such as education or medical care to add freshness to the boring teaching content, and also improve the user's willingness to use. For the system to be opened anytime and anywhere, it increases the convenience and improves the efficiency.

2.5.7. System Contribution

This research utilized the method of real-time detection of interactive computing between the front-end web page and the back-end server, so as to avoid the computational delay due to the busy rendering of the 3D scene on the web page. It can effectively provide a real-time preview function of scenes that require a large number of renderings, which is convenient for users to confirm the recognition effect. Hence, the external factors such as the lens angle can be adjusted in real time.

Furthermore, we used JSON file as the storage format also allows future avatar system developers to have higher scalability when applying their output files. At the same time, because the avatar is not stored in the output JSON file, practitioners can choose different avatar to accompany the challenges according to their preferences. Such a flexibility, we believe that it will increase user's willingness to challenge and reduce user's learned helplessness sense. However, such a guess can be a further research topic for our team.

Compared with other similar system technologies, this system lowers the threshold for creating virtual character actions, allowing recorders, such as teachers, rehabilitation practitioners, etc., to create teaching action files in a more intuitive and friendly way, so as to establish virtual companions to assist learners, for example, students, rehabilitators, etc., to achieve their challenges.

The myKLA2 toolset combines virtual characters to create a platform that provides JSON files for editing and testing. It is hoped that it can be applied to education and rehabilitation. If it is used in education, the teacher can use this system to see whether the actions shown on the avatar in the JSON file recorded by him meet his needs, and then he can make special marks on the key actions that the students want to follow and record them. To explain and teach students, for example, when the physical education instructor wants to demonstrate the movement and let the students practice together.

If it is used in rehabilitation, rehabilitators can also use this system to view their JSON files previously recorded, and then make special marks on the key actions that they want patients how to follow and record them to remind patients for their next actions.

2.6. Conclusion

Most advanced countries have listed information technology as fundamental education. However, seldom tools could be reconfigured after them being published for learners of multiple genders. We adopted the CPS theory and tried to design and develop a series of toolsets, myKLA and myKLA2, to design and record the required actions for specific selective actors. Also, the actor model can be designed by the users themselves. We hope most toolsets can meet the needs of students with multiple gender attributes. Our research team revised our toolsets that make them be utilized and reconfigured through a series of improvement processes for the educational aids. Also, we hope that the research results can become a reference toolsets for the development and design of educational tools as well as gradually expand the application to the selection of educational tools for preschool, school-age, adults, and the elderly.

2.7. Suggestions

Our governmental sponsor did a really good job during this disease period for processing the research postpone application. During the research period, everyone suffers the COVID-19 impact and most of us need to change our regular working procedures. For example, the students in my freshman course, Introduction to Software Engineering and Programming, that is, we focuses on the Python programming, however, some CoVID-19 infection-confirmed students and self-isolation students are absent in my class every week. Such a situation is quite difficult to proceed original planned assessment for our developed educational tools. Even we did our assessment, undoubtedly, the outcomes are predictable and down-gradation. Hence, the whole project might be negative. Normally, the research sponsor can actively provide postpone method to let all of the projects can smoothly execute their researches until the COVID-19 disappeared, not just asked applier to apply and change their research date again.

2.8. Difficulties We Met

Under this research year, we met the COVID-19 disease and it is still existed. Originally, our research team discussed and planned to apply postpone our schedule from NSTC. However, we cannot guarantee our project can be fulfilled during unpredictable disease period. Therefore, we cut off most physical experiments of our assessment for our developed educational tools at colleges and senior schools and put much efforts on the design and development of our educational tools. Fortunately, our research team developed a set of toolsets from myKLA to myKLA2.

3. Appendix

附件三

科技部補助專題研究計畫成果彙整表

計畫主持人：鄭伯壎			計畫編號：MOST 110－2629－E－017－001－		
計畫名稱：科技教具之性別可供性分析與軟硬體性別重構工程(L01)					
成果項目			量化	單位	質化
國內	學術性論文	期刊論文		篇	
		研討會論文	3		1. 劉姿吟, 趙詩越, 陳品蓉, 陳立偉, 鄭伯壎*, "以影像辨識為基礎之虛擬肢體互動應用 (Interactive Application on Virtual Limbs by Image Recognition)," 第 18 屆台灣軟體工程年會(TCSE-2022), 台北政治大學, June 24-25, 2022, pp. 428-432. 2. 趙詩越, 劉姿吟, 陳品蓉, 陳立偉, 鄭伯壎*, "虛擬肢體動作編輯系統之工具實作 (Practical Tool on Editing System for Virtual Limb Movements)," 第 18 屆台灣軟體工程年會(TCSE-2022), 台北政治大學, June 24-25, 2022, pp. 567-570.【佳作海報論文獎】 3. 陳品蓉, 趙詩越, 劉姿吟, 陳立偉, 鄭伯壎*, "以影像辨識為基礎之頭部部位互動偵測與多點即時運算 (Interactive Detection and Multiple Points Real-time Computation on Parts of the Head by Image Recognition)," 第 18 屆台灣軟體工程年會(TCSE-2022), 台北政治大學, June 24-25, 2022, pp. 571-574.
		專書		本	
		專書論文		章	
		技術報告		篇	
		其他		篇	

國外	學術性論文	期刊論文	(2)	篇	1. P. H. Cheng*, L. W. Chen, "Online Three-in-one Cross-reference Programming Educational Environment," Computer Applications in Engineering Education, 2022. (Submitted).【SCI】 2. P. H. Cheng*, L. W. Chen, P. R. Chen, S. Y. Chao, T. Y. Liu, "A Reconfigurable Interactive Visualization Leverage Technique for Gender-free Educational Actor-based Design," Computer Applications in Engineering Education, 2022. (Submitted).【SCI】
		研討會論文			
		專書		本	
		專書論文		章	
		技術報告		篇	
		其他		篇	
參與計畫人力	本國籍	大專生	4	人次	兼任研究助理 1. 趙蘭英(碩士級) 2. 王亭雅(學士級) 3. 趙詩越(學士級) 4. 劉姿吟(學士級) 5. 李柏寬(學士級)
		碩士生	1		
		博士生			
		專任人員(博士級)			
		專任人員(非博士級)			
	非本國籍	大專生			
		碩士生			
		博士生			
		專任人員(博士級)			
		專任人員(非博士級)			

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	參與本研究計畫之兩位女性大學部學生，因為一起開發此計畫之雛型系統，並準備爭取直接逕行於本系研究所攻讀碩士學位，至於結果尚待錄取名單公布後，此狀況隱含顯示本研究計畫的執行對女性工程師的人才培育效果有一定的助益，同時也因為強化培育女性工程師的向度，導致本實驗室近兩年內的實驗室成員都是以女性學生為主，對後續的研究與推廣都有一定的幫助與效益。

110年度專題研究計畫成果彙整表

計畫主持人：鄭伯壎			計畫編號：110-2629-E-017-001-		
計畫名稱：科技教具之性別可供性分析與軟硬體性別重構工程(L01)					
成果項目			量化	單位	質化 （說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文	0	篇	
		研討會論文	3	篇	1. 劉姿吟, 趙詩越, 陳品蓉, 陳立偉, 鄭伯壎*, "以影像辨識為基礎之虛擬肢體互動應用 (Interactive Application on Virtual Limbs by Image Recognition)," 第18屆台灣軟體工程年會(TCSE-2022), 台北政治大學, June 24-25, 2022, pp. 428-432. 2. 趙詩越, 劉姿吟, 陳品蓉, 陳立偉, 鄭伯壎*, "虛擬肢體動作編輯系統之工具實作 (Practical Tool on Editing System for Virtual Limb Movements)," 第18屆台灣軟體工程年會(TCSE-2022), 台北政治大學, June 24-25, 2022, pp. 567-570.【佳作海報論文獎】 3. 陳品蓉, 趙詩越, 劉姿吟, 陳立偉, 鄭伯壎*, "以影像辨識為基礎之頭部部位互動偵測與多點即時運算 (Interactive Detection and Multiple Points Real-time Computation on Parts of the Head by Image Recognition)," 第18屆台灣軟體工程年會(TCSE-2022), 台北政治大學, June 24-25, 2022, pp. 571-574.
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					based Design," Computer Applications in Engineering Education, 2022. (Submitted).【SCI】
		研討會論文	1		1. Y. W. Pu, P. H. Cheng*, L. W. Chen, "Research on Online Programming Educational Tool: Case Study on A Three-in-one Environment," Proceedings of the International Conference on Education and New Developments (END-2022), Volume 2, Madeira Island, Portugal, June18-20, 2022, pp. 406-410.
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
參與計畫人力	本國籍	大專生	4	人次	1.王亭雅(學士級) 2.趙詩越(學士級) 3.劉姿吟(學士級) 4.李柏寬(學士級)
		碩士生	1		1.趙蘭英(碩士級)
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
其他成果 （無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）			參與本研究計畫之兩位女性大學部學生，因為一起開發此計畫之雛型系統，並準備爭取直接逕行於本系研究所攻讀碩士學位，至於結果尚待錄取名單公布後，此狀況隱含顯示本研究計畫的執行對女性工程師的人才培育效果有一定的助益，同時也因為強化培育女性工程師的向度，導致本實驗室近兩年內的實驗室成員都是以女性學生為主，對後續的研究與推廣都有一定的幫助與效益。		