Human Interaction and Emerging Technologies (IHIET 2023), Vol. 70, 2023, 334–347
https://doi.org/10.54941/ahfe1002960

Engaging Students through Conversational Chatbots and Digital Content: A Climate Action Perspective

Thomas Menkhoff[1] and Benjamin Gan Kok Siew[2]

[1]Lee Kong Chian School of Business (LKCSB), Singapore Management University (SMU), 81 Victoria St, Singapore 188065, Republic of Singapore
[2]School of Computing and Information Systems, Singapore Management University (SMU), 81 Victoria St, Singapore 188065, Republic of Singapore

ABSTRACT

In this case study, we report experiences developing a conversational chatbot as a pre-class and post-class engagement tool for undergraduate students enrolled in sustainability-related courses aimed at educating them about the severity of climate change and the importance of climate action by offsetting one's carbon footprint (e.g, by planting trees or mangroves in SEA). The intitiative supports the university's sustainability efforts in general and our new sustainability major in particular aimed at helping students to achieve sustainability-related learning outcomes with reference to climate change and climate action (SDG 13), one of the 17 Sustainable Development Goals established by the United Nations in 2015.

Keywords: Chatbots, Climate change, Climate action, Student engagement

INTRODUCTION

In support of Singapore's national sustainability efforts such as Singapore's Green Plan 2030 (MOE, 2022) and newly established sustainability courses at local universities such as SMU's sustainability major, research efforts are ongoing to demonstrate the feasibility of building an educational 'Climate Bot 1.0' prototype as POC that can help and engage undergraduate students to achieve sustainability-related learning outcomes with reference to climate change mitigation and adaptation efforts in support of Sustainable Development Goal 13 'Climate Action' (UNDP, n.d.). Developing a greater interest in climate action is critical as the impact of climate change is something that everyone will inevitably experience and be confronted with regardless of one's preferences and mindsets. "Climate action means stepped-up efforts to reduce greenhouse gas emissions and strengthen resilience and adaptive capacity to climate-induced impacts, including: climate-related hazards in all countries; integrating climate change measures into national policies, strategies and planning; and improving education, awareness-raising and human and institutional capacity with respect to climate change mitigation, adaptation, impact reduction and early warning" (https://www.sdfinance.undp.org/content/sdfinance/en/home/sdg/goal-13--climate-action.html).

Research studies on Chatbots have underscored the positive effect of bots on students' learning in educational institutions in terms of conveniency, satisfaction, engagement, and motivation (Kumar, 2021; Smutny & Schreiberova, 2020; Martha & Santoso, 2019). What is less clear is whether (and if yes, how and why) Chatbot-centered experiential activities with reference to sustainability and climate change can reduce the inhibitors of practice (action), e.g., by directing learners to 'useful' approaches as potential nudges (Siipi & Koi, 2022) for personal climate action such as contributing to the restoration of degraded mangroves in Asia by NGOs as an offsetting approach facilitated by technology platforms such as *Handprint* (n.d.) rather than coercing them.

Our teaching and learning-related 'Climate Bot 1.0' project aims to develop a conversational climate Chatbot prototype as an educational engagement tool (Mandernach, 2015) with relevant personal digital content (eg carbon footprint, carbon markets, carbon pricing etc.) for undergraduate students enrolled in sustainability-related courses to educate them about the severity of climate change and to help them to enhance their personal resilience (Nelson et al., 2007; Fletcher & Sarkar, 2013) and capacity to adapt to it. An example of a related learning outcome (to be measured and evaluated via a pre-test/post-test design) would be that the Chatbot helps students to become more aware of effective ways to adapt to climate change so that they, for example, appreciate the urgency of reducing one's own carbon emissions (= footprint) by lowering their beef consumption.

By using Google's Dialogflow as the 'brain' (program) of the proposed Chatbot, the bot prototype will help to act as an emphatic explainer to help students internalise relevant sustainability and climate change-related learning content by using 'attractive' personas (e.g., *Doubtful Debbie vs. Climate Conscious Chrissy)*. An important aspect that will be ascertained is the bot's capacity for enhancing personal resilience in the context of enhanced climate adaptation competencies (Campbells-Sills, 2007; Lake, 2000; Pelling et al., 2021; Busic & Schubert, 2022). This tenacity capacity building facet of 'green' chatbots has not been systematically examined (Cacanindin's, 2020).

The climate bot prototype will create a novel, interactive learning experience aimed at achieving key learning outcomes related to climate change mitigation and adaptation efforts in support of SDG13 Climate Action (see Table 4). We regard this as a meaningful teaching and learning experiment in view of the ongoing climate crisis and the popularization of artificial intelligence in education (Singh, 2018; Davenport & Ronanki, 2018). The findings generated from this project will make important theoretical contributions to the literature on effective climate engagement and personal resilience in the face of climate change which can be extended to other IHLs to nurture the next generation of sustainability leaders.

REVIEW OF EXISTING LITERATURE

Conceptually, the proposed project relates to the study of technology-mediated learning (Picciano, 2011) and the input-process-output framework developed by Winkler & Söllner (2018) to guide the deployment of educational bots. We propose to build a conversational climate Chatbot prototype as minimum viable product (MVP) that can interact with students asynchronously. We shall consider students' dispositions at the input level such as the level of climate change awareness and know how in relation to the technology enhanced learning process. The chatbot conversation will react on individual intents aimed at achieving course related learning outcomes (see Table 4).

Conveniency, satisfaction and engagement have been highlighted in previous studies as benefits of using conversational pedagogical agents (= "Chatbots") in teaching and learning (Smutny & Schreiberova, 2020; Martha & Santoso, 2019; Satow, 2017; Fadhill & Villaforita, 2017; Pereira, 2016; Kim & Baylor, 2007). Bot examples include the chatbot creator Botsify (https://botsify.com), CourseQ (an interactive course recommendation system) or Hubert, a conversational feedback tool (https://hubert.ai/thankyouforjoining). High levels of student engagement can translate into better learning outcomes (Handelsman et al., 2005) provided learners are motivated and extrinsic factors that influence the learning process such as the adequacy of the chosen teaching and learning device as well as the 'right' instructional strategies are in place. The scarce literature on climate bots is mostly positive regarding their technological power to promote climate-friendlier behavior. Examples include Hillebrand & Johannsen (2021) study on "KlimaKarl" to sensitize office workers to behave more climate-friendly; Slupik et al.'s "Eco-Bot" project with its focus on energy consumption; Tsai & Kang's (2019) "Ask Diana" chatbot for water-related disaster management; or Cacanindin's (2020) functionality review of chatbot development platforms in the context of green(er) food consumption.

There is an increasing use of Chatbots to inspire pro-environmental behaviour by incorporating sustainability-related content. However, there is a gap of knowledge when it comes to understanding their effectiveness as an experiential learning tool in higher education courses where the subject matter focus is on enhancing climate change adaptation and personal resilience (Winkler & Söllner, 2018:24).

Resilience is posited by many IHLs as an important learning outcome because it represents a coping mechanism for challenging experiences (Leipold & Greve, 2009; Lake, 2020). Negative emotional reactions to traumatic stress (Tielman et al., 2015) or extreme weather experiences (Reser & Swim, 2011) such as floods and urban heat can have undesirable impacts on wellbeing. The latter can also be an important motivation for personal action on climate change (Ogunbode et al., 2019; Nazarian et al., 2020). In the context of the proposed project, we shall shed light on this paradox and gather experiences with a virtual assistant (= bot) solution that could help to reduce the inhibitors of practice (action) by directing learners to useful environmental domain knowledge and explanatory approaches as potential nudges (Siipi & Koi, 2022; Vilgalys, 2018) towards personal climate action. The vision is that the climate bot contributes towards students' climate-friendly behaviour and active decarbonisation efforts, e.g., by enabling them to calculate their own carbon footprints and linking them to concrete offsetting approaches (Hillebrand & Johannsen, 2021).

We argue that Chatbots as conversational pedagogical agents can engage learners because of their built-in ability to converse and to form user-relevant responses from curated domain knowledge databases or search engines. Key **research questions** include:

RQ1: Do (if yes, how and why) conversational Chatbots focusing on climate change content motivate and engage students to increase their understanding of the challenges, concepts and solutions related to climate change mitigation and adaptation efforts?

RQ2: Do (if yes, how and why) conversational Chatbots that help users to learn about practical climate change solutions (e.g., through built-in positive messages about green innovations) enhance students' personal resilience in the face of climate change?

RQ3: Does (if yes, why and how) the participation in Chatbot-related teaching and learning activities (including the actual bot development) with focus on sustainability and climate change matters motivate and engage students towards concrete climate action (from greener transport choices to diet) they can take to limit some of the negative effects of climate change?

CONCEPTUAL MODEL: MOTIVATION, ENGAGEMENT, PERSONAL RESILIENCE

Motivation is central to student engagement and performance (Augustyanak, 2016). Hence, it is studied as an important variable in this research project (RQs 1+3). A well-researched theoretical framework for studying motivation is the Self-Determination Theory (SDT) by Deci & Ryan (2000). In designing our data collection tools, we shall use The Intrinsic Motivation Inventory (IMI) as derived from SDT. This valid and reliable measurement instrument has been widely used to measure intrinsic motivation via several sub-scales comprising interest/enjoyment, perceived competence, effort/importance, pressure/tension, and value/usefulness. Intrinsic motivation refers to doing things "for their own sake" or acting as the task is perceived to be inherently interesting or pleasant to the individual. Intrinsic motivation is associated to positive learning outcomes in formal education such as school performance and achievements. SDT posits that humans have proactive tendencies that are manifested in learning, mastery and connection with others (Navarro et al., 2020).

Student *engagement* is an integral component of learning effectiveness (Mandernach, 2015). To measure students' *engagement* (RQs 1+3), we shall use the robust Student Course Engagement Questionnaire (SCEQ) as scale of reference (Mandernach, 2015). The SCEQ items capture four dimensions of engagement: (i) skills engagement, (ii) participation/interaction, (iii) emotional engagement, and (iv) performance engagement. The results will provide us with deeper insights into the level of students' motivation and types of engagement vis-à-vis the expected climate bot-induced learning outcomes.

Personal Resilience (Nelson et al., 2007; Ntontis et al., 2018) can arguably help to deal with the impacts of climate change (RQ2). According to psychological research (Lake, 2020; Busic & Schubert, 2022), individuals with a positive outlook on life and well-developed coping strategies for dealing with the psychological impacts of climate change will probably be better suited to manage the stressful effects of extreme weather events, the urban heat

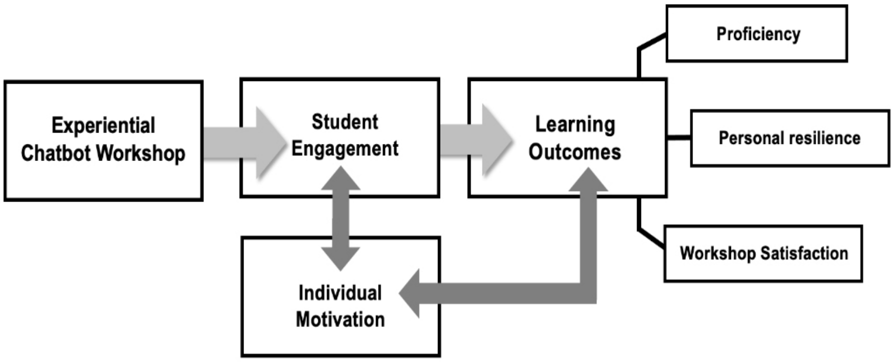

Exhibit 1: Conceptual Model for Engagement, Motivation and Learning Outcomes.

effect and global warming: "Individuals and communities that prepare for the harmful physical, economic, and psychological impacts of climate change by focusing on positive messages and practical solutions will probably be more resilient in the face of unforeseen circumstances that will arise in the context of unchecked climate change" (Lake, 2020). Accordingly, we plan to integrate "simple techniques such as the use of vivid images to convey positive messages about green innovations in energy production and emerging technologies that may slow down the rate of global warming" (Lake, 2020) into the bot based on Lake's assumption that this will enhance students' psychological resilience in the face of climate change. To measure students' resilience and the potential of our chatbot prototype to enhance their coping abilities, we shall adapt items from the Connor–Davidson Resilience Scale (Campbell-Sills & Stein 2007; Luthar et al., 2000) such as 'Can deal with whatever comes'. To what extent bot design components such as dynamic avatars (Kao & Harrel, 2016) as virtual climate advocates can help students to enhance personal resilience will be examined. Exhibit 1 illustrates our conceptual model.

We hypothesize that students graduating from a Chatbot-centric sustainability course featuring an educational climate bot prototype will have a better understanding of climate-related topics and be equipped with critical proficiencies in relation to climate change solutions. This in turn will help them succeed in achieving pertinent learning outcomes (see Table 4).

A key outcome of the proposed persona-focused 'Climate Bot 1.0' project is the development of an innovative, conversational climate Chatbot as an engagement tool with 'interesting', digital content. We envision that the prototype will provide an inspiring learning experience for undergraduate students enrolled in sustainability-related courses aimed at educating them about the severity of climate change and the urgency of personal climate action, e.g. by linking carbon emissions caused by personal energy consumption to the need for offsetting one's carbon footprint by planting trees or mangroves.

The proposed project benefits from a recently completed SMU research project on engaging students enrolled in the P.I.'s course 'Doing Business with A.I.' which successfully featured a 3-hours long experiential Chatbot

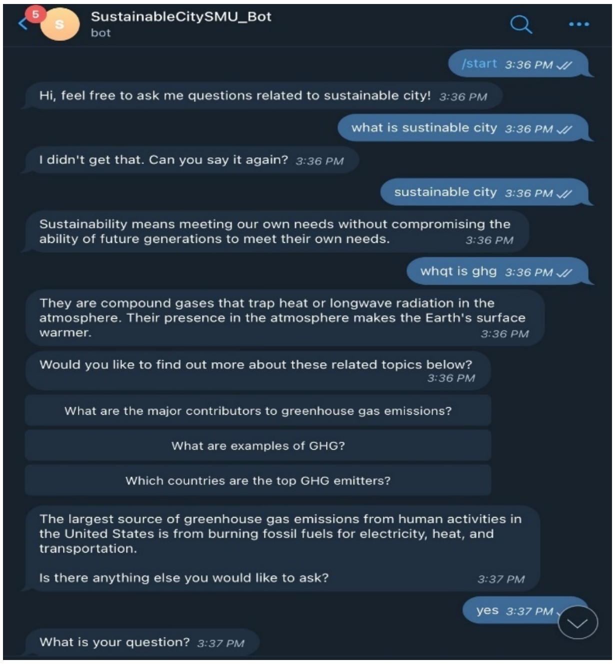

Exhibit 2: Simple Sustainability Bot Demo.

workshop aimed at educating learners about automated tools based on natural language processing (Menkhoff & Teo, 2021). Initial learning process and outcome-related experiences in a recent postgraduate development workshop organised by the 1st author at SMU with focus on sustainability-related content were positive. Exhibit 2 shows a demo that we used during the workshop.

The proposed climate chatbot prototype will effectively educate and engage (Handelsman et al., 2005) students with regards to important sustainability and climate change related concepts such as 'carbon neutrality', 'carbon footprint measurement', 'carbon sequestration', 'carbon pricing' etc. An example of a desired learning outcome would be that the chatbot use helps students to appreciate the importance of reducing one's own greenhouse gas emissions and to get involved in conservation efforts (see Table 4).

APPROACH AND IMPLEMENTATION

Bots have been effectively deployed as e-tutors during distance learning (Clarizia et al., 2018; Tamayo et al., 2020). They have been creatively used to facilitate the learning of a foreign language (Nghi et al., 2019; Kim et al., 2019). Aberg's study (2017) focuses on chatbots that can motivate people to live more sustainable lives. Groza & Toniuc (2019) elaborate on the technicalities of adding ontologies to conversational climate bots. Chatbots facilitate student-to-student and student-to-faculty communication just like in a classroom towards knowledge construction (Moraes & Fernandes, 2019). We hypothesize that the proposed Chatbot prototype as an argumentative agent

Table 1. Bot development process.

Bot Development Process	Process Activities
Preparation	Gathering content, preparing the content (based on course XYZ) to 'feed' the chatbot. Building the logical flow (backend) for the chatbot.
Prototyping and testing	The team will work on the backend to ensure that the bot is working and that it can execute the desired actions as programmed (e.g., matching user intent to appropriate responses from the database). Checks will be performed to identify potential bugs and eliminate errors.
User Testing	A small sample of users enrolled in relevant modules will test the prototype. The feedback will be used to further improve it before the pilot.
Pilot Phase (Field Test)	Bot deployment (validation and adjustments), data collection, analysis

for climate change will educate, sensitize and engage undergraduate students so that they take the climate issue seriously and appreciate the urgency to combat climate change through climate-friendlier behavior. We also presume that an effectively designed climate bot will enhance students' personal resilience in the face of climate change.

A good Chatbot knowledge base needs a strong foundation, ie user-relevant data as well as a solid data collection, data processing and data storage system so that the right actionable information can be retrieved and shared by users. Natural language processing (NLP) enables the bot to read texts and to understand speech with the help of a syntax tree (that represents the different syntactic categories of a sentence) and a semantic lexicon (a digital dictionary of words labeled with semantic classes so associations can be drawn between words that have not previously been encountered).

The pilot phase (see Table 1) will span across 2 academic terms with data collection in 4 relevant courses and two schools (COR MGMT2207 Innovations for Asia's Smart Cities; IS211 Interaction Design and Prototyping; COR MGMT342 Org Aspects of Sustainable Innovation; SMT112 Smart City Technologies; MGMT240 Doing Business with AI) with about 200 undergraduates. After collecting and evaluating relevant feedback and data, we can further train the Chatbot and add smarter capabilities for future iterations. We assume that the new digital asset will be scalable to other course(s) and stakeholders.

Conversational AI Chatbots enable students to learn through online messages just like by prompting and facilitating an ongoing conversation, and they deliver actionable content. The proposed climate bot will help the instructor to assess students' levels of understanding and knowledge about urgent climate matters by recording their answers and responses. To engage learners, we will create fictional characters such as *Reluctant Roy* vs. *Climate Conscious Chrissy* to represent a particular user type so that the climate Chatbot

Table 2. Learning objective, measures and indicators of success.

Learning Objective	Assessment	Indicators of Success
Example: To examine and explain the concept of carbon pricing Adaptation in Climate Bot Ver 1.0 By contrasting two personas such as *Reluctant Roy (RR)* and *Climate Conscious Chrissy (CCC)*, the bot will introduce students in an engaging manner to the instrument of carbon pricing that captures the external costs of greenhouse gas (GHG) emissions, including the implications of 'RR's reluctance to pay' and 'CCC's willingness to make financial (tax) contributions' as *reductions in future raises*.	Reviews, quizzes, pre-test and post-test assessments.	By framing the cost issue differently consistent with the psychological principal of *loss aversion*, students realise the necessity of making financial contributions (e.g. carbon tax) to combat climate change as reductions in future raises rather than as perceived 'losses'.

effectuates students' greater appreciation of relevant topics such as carbon pricing (see Table 2).

Climate Bot – Instructional Strategies

As a smart teaching and learning tool in sustainability-related courses, the proposed climate bot will provide relevant explanatory pedagogical content and administer learning tests (Abbasi & Kazi, 2014) to help students to become independent, climate-wise learners as indicated in Table 3.

We plan to integrate the Chatbot into Slack, a popular messaging platform currently in use in many universities (Shim et al., 2021). Slack provides several features such as channels, threads, mentions and notifications designed for efficient communication and collaborative learning. Via Slack's API, the Dialogflow Chatbot can engage in a live conversation with the user. The user's messages are fed into Dialogflow's NLP engine which analyses the intent and semantics behind the input messages. Next, it will produce appropriate replies based on pre-trained models. By using different personas as part of the instructional method with emphasis on climate change-related domain knowledge and ontologies as well as role play learning, students will be encouraged to think about the climate topic from various perspectives, a refreshing change to the conventional seminar-style lesson format.

To answer the three research questions, a mixed-method methodology will be used such as half-structured interviews with undergraduate students and student surveys (using a pre-test and post-test design) of 200 learners enrolled in four relevant courses over 2 academic terms (see above). Our interests relate to the pre- and post-course level of students' (i) knowledge and concerns about the challenges, concepts and solutions related to climate change mitigation and adaptation efforts (RQ1), (ii) personal vulnerability

Table 3. Climate Bot – Instructional Strategies.

Instructional Strategy	T&L Activities (administered by 'Climate Bot')	Impact on Learning Outcome
Spaced Practice	Out-of-class: The 'Climate Bot' sends out short MCQ quizzes to students who attempt the quiz at their own time (within the deadline given).	Spaced (self-paced) learning and revision of climate change knowledge (e.g., climate action) covered in class. Out-of-class engagement via chatbot to reinforce concepts taught.
Socratic Questioning	In relation to topic(s) covered during class, the Climate Bot posts questions and invites students to respond. *E.g., "Why do you think is it so challenging to reduce the urban heat effect in high-rise Singapore?"*	Open discussion leads to improved critical thinking. Students' responses are consolidated from Dialogflow's backend to be used to build the knowledge base.
Guided Inquiry	The Climate Bot conveys assignments / questions and suggests readings to students. Learners interact with the chatbot, and they may collaboratively share additional materials.	Students utilize suggested resources to broaden their knowledge base and know why of relevant climate change concepts and solutions. Learning is multi-directional: some resources are curated by instructors and shared with students via the 'Climate Bot'; students can also suggest relevant ideas and share materials with the instructors via the chatbot. Useful content and knowledge can be examined and discussed during class (peer-to-peer learning).
Role-play	The Climate Bot randomly assigns a persona to students who are encouraged to discuss the selected issue (e.g., eco pessimism) with the chatbot using the persona's perspective. Instructor may select student for a short presentation using the persona assigned.	Students practice empathy and reflective learning by considering different perspectives leading to a better understanding of the climate-related challenge and possible solutions. This is a critical, relevant skillset in the context of climate action (and beyond), e.g., understanding why need climate optimism or getting stakeholder buy-in.
Self-practice	The Climate Bot consolidates, and processes information shared by students to improve the knowledge base. Chatbot responses guide/assist/provide feedback to student.	Students participate in self-directed hands-on activities to 'feed' the chatbot with information (= 'Intents' on Dialogflow), following the demonstration by the instructor. Concurrently, learners are actively engaged in the process of enhancing the Chatbot.
Discussion	The Climate Bot prompts students to respond to questions raised in class.	Collaborative learning motivates and improves student communication. It increases students' knowledge retention, self-esteem and responsibility.

Table 4. Learning Outcomes (Examples) in Relation to the 3 Research Questions.

RQs	Learning Outcomes (Examples)
RQ1	Topics: Carbon Footprint Measurement, Ways to Adapt to Climate Change, Urban Climate Action Projects as Solutions (Positive messaging / insights related to the above: Singapore's Green Plan is an example of a Climate Change Adaptation Plan) Define the terms 'carbon footprint', 'climate adaptation', and 'climate action' as well as their significance / urgency.
RQ2	Topic: Mangrove Sequestration (Positive messaging / insights related to Personal Resilience as an important Climate Adaptation Skill: Mangroves can sequester four times more carbon than rainforests!) Explain the importance of carbon sequestration and what can be done to remove, capture (or sequestrate) carbon dioxide from the atmosphere to slow or reverse atmospheric CO2 pollution and to mitigate or reverse climate change.
RQ3	Topic: Emotional Engagement towards Concrete Climate Action (Positive messaging / insights related to the above: Participating in drafting and implementing a Community Climate Action Plan is a commendable contribution to Climate Action). Demonstrate greater awareness of climate action and the need to act.

and resilience in the face of climate change (RQ2), and (iii) concrete climate actions which they can take (from transport choices to diet) to limit some of the negative effects of climate change (RQ3). We will compare attitudinal items across gender, age, study area, previous work experience etc. Actual students' performance data from cumulative assessments and end of course evaluations will be taken into consideration to evaluate the achievement of desired learning outcomes. Besides the collection of primary interview and survey data, triangulation of findings will be carried out to increase the credibility and validity of the results investigation by means of class observations, consultations of Chatbot experts and analysing documents / media reports.

CONCLUSION

Several research studies have underlined the potentially positive effect of Chatbots on students' learning in educational institutions ranging from primary schools to IHLs. "Conveniency", "satisfaction", "engagement" and "motivation" have been highlighted in previous studies as benefits of using conversational pedagogical agents (= "Chatbots") in teaching and learning (Smutny & Schreiberova, 2020; Martha & Santoso, 2019; Satow, 2017; Fadhill & Villaforita, 2017; Pereira, 2016; Kim & Baylor, 2007). We argue that conversational chatbots can help to tackle teaching and learning challenges such as students' climate change ignorance / indifference, lack of confidence in calculating one's own carbon footprint, not knowing why personal climate action is important and how it can contribute to active decarbonisation etc. to mitigate climate change etc. Our ongoing project will help to profile learners, act as a teaser to review and internalise relevant climate change and carbon footprint related learning content and enable students to appreciate the urgency of concrete carbon offsetting opportunities and enhance personal resilience.

REFERENCES

Abbasi, S. and Kazi, H. (2014). Measuring Effectiveness of Learning Chatbot Systems on Student's Learning Outcome and Memory Retention. Asian Journal of Applied Science and Engineering 3(7):57–66.

Aberg, J. (2017). Chatbots As A Mean To Motivate Behavior Change: How To Inspire Pro-Environmental Attitude with Chatbot Interfaces. Umeå University, Faculty of Science and Technology, Department of Applied Physics and Electronics. Umeå University. (Civilingenjörsprogrammet i Interaktion & Design). Independent thesis / advanced level.

Augustyniak, R.A., Ables, A.Z. & Guilford, G. (2016). Intrinsic Motivation: An Overlooked Component for Student Success. Advances in Physiology Education, 40(4): 465–466. https://doi.org/10.1152/advan.00072.2016

Berinato, S. (2017). Inside Facebook's AI Workshop - At the Social Network Behemoth, Machine Learning has become a Platform for the Platform, Harvard Business Review (https://hbr.org/2017/07/inside-facebooks-ai-workshop).

Busic, A. & Schubert, R. (2022). Social Resilience Indicators for Pandemic Crises (March 29, 2022). Available at SSRN: https://ssrn.com/abstract=3938198 or http://dx.doi.org/10.2139/ssrn.3938198

Campbell-Sills, L. & Stein, M.B. (2007), Psychometric Analysis and Refinement of the Connor–Davidson Resilience Scale (CD-RISC): Validation of a 10-Item Measure of Resilience. Journal of Traumatic Stress, 20(6):1019–1028.

Cacanindin, N.M. (2020). Greening Food Consumption Using Chatbots as Behavioral Change Agent. Journal of Advanced Research in Dynamical and Control Systems 12(01-Special Issue): 204–211 DOI: 10.5373/JARDCS/V12SP1/20201064

Chavan, M. (2011). Higher Education Students' Attitudes Towards Experiential Learning in International Business. Journal of Teaching in International Business, 22(2):126–143.

Clarizia, F., Colace, F., Lombardi, M., Pascale, F., & Santaniello, D. (2018). Chatbot: An Education Support System for Student. Cyberspace Safety and Security, 11161, 291–302. Retrieved 01 July 2021, from https://doi.org/10.1007/978-3-030-01689-0_23.

Davenport, T.H. & R. Ronanki (2018). Technology - Artificial Intelligence for the Real World, Harvard Business Review, January–February Issue (https://hbr.org/2018/01/artificial-intelligence-for-the-real-world).

Fadhill, A. & Villaforita, A. (2017). An Adaptive Learning with Gamification & Conversational UIs: The Rise of CiboPoliBot. UMAP '17: Adjunct Publication of the 25th Conference on User Modeling, Adaptation and Personalization (July), pp. 408–412 https://doi.org/10.1145/3099023.3099112.

Fletcher, D. & Sarkar, M. (2013). Psychological Resilience: A Review and Critique of Definitions, Concepts, and Theory. European Psychologist, 18(1):12–23. doi: 10.1027/1016-9040/a000124

Gray, A. (2016). The 10 skills you need to thrive in the Fourth Industrial Revolution, World Economic Forum (https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/).

Groza, A. & Toniuc, D. (2019). Explaining Climate Change with a Chatbot based on Textual Entailment and Ontologies. https://www.researchgate.net/publication

/337428702_Explaining_climate_change_with_a_chatbot_based_on_textual_entailment_and_ontologies

Handelsman, M., Briggs, M., Sullivan, W.L. & Towler, A. (2005). A Measure of College Student Course Engagement. The Journal of Educational Research, 98(3):184–191. https://doi.org/10.3200/JOER.98.3. 184–192

Hillebrand, K. & Johannsen, F. (2021). KlimaKarl – A Chatbot to Promote Employees' Climate-Friendly Behavior in an Office Setting. In: The Next Wave of Sociotechnical Design, Proceedings of the 16th International Conference on Design Science Research in Information Systems and Technology, DESRIST 2021, Kristiansand, Norway, August 4–6 (2021), Editors: Leona Chandra Kruse, Prof. Dr. Stefan Seidel, Geir Inge Hausvik. Springer.

Kao, D. & Harrell, D. F. (2016). Exploring the Effects of Encouragement in Educational Games. ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI 2016).

Kim, Y., Baylor, A.L. and Shen, E. (2007). Pedagogical Agents as Learning Companions: The Impact of Agent Emotion and Gender. Journal of Computer Assisted Learning 23(3):220–234, 10.1111/j. 1365–2729.2006.00210.x

Kirkpatrick, D. (1996). Revisiting Kirkpatrick's four-level-model. Training & Development, 1:54–57.

Kumar, J.A. (2021). Educational Chatbots for Project-based Learning: Investigating Learning Outcomes for a Team-based Design Course. International Journal of Educational Technology in Higher Education, 18:65, https://doi.org/10.1186/s41239-021-00302-w.

Lake, J. (2015). The Integrative Management of PTSD: A Review of Conventional and CAM Approaches used to Prevent and Treat PTSD with Emphasis on Military Personnel, Advances in Integrative Medicine, Vol 2(1):13–23.

Lake, J. (2020). Enhancing Resilience in the Face of Climate Change. Psychology today, 19 February, https://www.psychologytoday.com/us/blog/integrative-mental-health-care/202002/enhancing-resilience-in-the-face-climate-change.

Leipold, B. & Greve, W. (2009). Resilience: A Conceptual Bridge between Coping and Development. European Psychologist, 14(1):40–50. doi: 10.1027/1016-9040.14.1.40

Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The Construct of Resilience: A Critical Evaluation and Guidelines for Future Work. Child Development, 71:543–562.

Mandernach, B.J. (2015). Assessment of Student Engagement in Higher Education: A Synthesis of Literature and Assessment Tools. International Journal of Learning, Teaching and Educational Research, Vol. 12(2):1–14.

Martha, A.S.D. & Santoso, H.B. (2019). The Design and Impact of the Pedagogical Agent: A Systematic Literature Review. The Journal of Educators Online, Vol. 16(1), https://www.thejeo.com/archive/2019_16_1/martha__santoso.

Menkhoff, T. & Teo, L. (2021). Evaluating the Effectiveness of Chatbots as Experiential Learning Tools in an Introductory 'Doing Business with A.I.' Course. Paper presented by Lydia Teo at the 2021 World Congress In Computer Science, Computer Engineering, and Applied Computing (CSCE'21) -- The 23rd International Conference on Artificial Intelligence. SPRINGER NATURE - Research Book Series Transactions on Computational Science & Computational Intelligence.

MOE, 2022. Strengthening Our Contributions Towards the Green Economy and Empowering the Next Generation of Sustainability Leaders. Press release published on 08 March 2022, https://www.moe.gov.sg/news/press-releases/20220308-strengthening-our-contributions-towards-the-green-economy-and-empowering-the-next-generation-of-sustainability-leaders

Moraes, N.A. and Fernandes, M. (2019). Chatbot and Conversational Analysis to Promote Collaborative Learning in Distance Education. 2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT), 15–18 July 2019, pp. 324–326. 10.1109/ICALT.2019.00102.

Navarro, O. Francisco Javier Sánchez-Verdejo Pérez, Juana María Anguita and Ángel Luis González Olivares (2020). Motivation of University Students Towards the Use of Information and Communication Technologies and Their Relation to Learning Styles. International Journal of Emerging Technologies in Learning, Vol. 15(15):202-218, DOI:10.3991/ijet.v15i15.14347.

Na-young Kim, Yoonjung Cha, & Hea-suk Kim. (2019). Future English Learning: Chatbots and Artificial Intelligence. Multimedia-Assisted Language Learning, 22(3), 32–. Retrieved 01 July 2021,from https://search.library.smu.edu.sg/permalink/65SMU_INST/1ba19kd/cdi_kiss_primary_3703643

Nazarian, N., S. Liu, M. Kohler, J.K.W. Lee, C. Miller, W.T.L Chow, S.B.B. Alhadad, A. Martilli, M.Quintana, L. Sunden, and L. Norford (2020). Project Coolbit: Can Your Watch Predict Heat Stress and Thermal Comfort Sensation? Environmental Research Letters. DOI: 10.1088/1748-9326/abd130 (Open Access)

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to Environmental Change: Contributions of a Resilience Framework. Annual Review of Environment and Resources, 32(1):395–419. doi: 10.1146/annurev.energy.32.051807.090348

Nghi, Tran & Huu Phuc, Tran & Nguyen Tat, Thang. (2019). Applying AI Chatbot for Teaching a Foreign Language: An Empirical Research. International Journal of Scientific & Technology Research, 8:897–902.

Ntontis, E., Drury, J., Amlôt, R., Rubin, G. J., & Williams, R. (2018a). Community Resilience and Flooding in UK Guidance: A Critical Review of Concepts, Definitions, and their Implications. Journal of Contingencies and Crisis Management, doi: 10.1111/1468-5973.12223

Ogunbode, C.A., Böhm, G., Capstick, S.B., Demski, C., Spence, A. and N. Tausch (2019). The Resilience Paradox: Flooding Experience, Coping and Climate Change Mitigation Intentions. Climate Policy, 19(6):703-715, DOI: 10.1080/14693062.2018.1560242

Ong, D.L., Shim, K.J. and Gottipati, S. (2021). Profiling Student Learning from Q&A Interactions in Online Discussion Forums. Proceedings of the International Conference on Computers in Education (ICCE 2021), Thailand, November 22-26, (pp. 251–260) Thailand.

Pereira, J. (2016). Leveraging Chatbots to Improve Self-guided Learning through Conversational Quizzes, TEEM '16: Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality, November, pp. 911–918, https://doi.org/10.1145/3012430.3012625.

Pelling, M., Chow, W.T.L., Chu, E., Dawson, R., Dodman, D. et al. (2021). A Climate Resilience Research Renewal Agenda: Learning Lessons from the COVID-19 Pandemic for Urban Climate Resilience. Climate and Development. DOI:10.1080/17565529.2021.1956411 (Open Access).

Picciano, A.G. (2011). Educational Leadership and Planning for Technology. Simon & Schuster/Prentice-Hall.

Reser, J. P. & Swim, J. (2011). Adapting to and coping with the Threat and Impacts of Climate Change. American Psychologist, 66(4):277–289. doi: 10.1037/a0023412

Ryan, R.M. & Deci, E.L. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. The American Psychologist, 55:68–78. 10.1037/0003-066X.55.1.68.

Ryan, R.M. & Deci, E.L. (2020). Intrinsic and Extrinsic Motivation from a Self-determination Theory Perspective: Definitions, Theory, Practices, and Future Directions. Contemporary Educational Psychology, 61:101860–. https://doi.org/10.1016/j.cedpsych.2020.101860

Satow, L. (2017). Chatbots as Teaching Assistants: Introducing a Model for Learning Facilitation by AI Bots, https://blogs.sap.com/2017/07/12/chatbots-as-teaching-assistants-introducing-a-model-for-learning-facilitation-by-ai-bots/.

Shibani, A., Koh, E., Lai, V. and Shim, K.J. (2017). Assessing the Language of Chat for Teamwork Dialogue. Journal of Educational Technology and Society, 20(2):224–237.

Shim, K.J., Gottupati, S. and Lau, Y.M. (2021). Flip & Slack - Active Flipped Classroom Learning with Collaborative Slack Interactions. Proceedings of the 29th International Conference on Computers in Education (ICCE 2021), Virtual Conference, November 22-26, (pp. 121-131).

Singh, S. (2018). AI and Chatbots in Education: What Does The FutureHold?
https://chatbotsmagazine.com/ai-and-chatbots-in-education-what-does-the-futurehold-9772f5c13960

Siipi, H. & Koi, P. (2022). The Ethics of Climate Nudges: Central Issues for Applying Choice Architecture Interventions to Climate Policy. European Journal of Risk Regulation, 13(2):218-235, DOI: https://doi.org/10.1017/err.2021.49.

Słupik, S., Kos-Łabędowicz, J. and Trzęsiok, J. (2021). An Innovative Approach to Energy Consumer Segmentation—A Behavioural Perspective. The Case of the Eco-Bot Project. Energies 14(12): 3556. https://doi.org/10.3390/en14123556

Smutny, P. & Schreiberova, P. (2020). Chatbots for Learning: A Review of Educational Chatbots for the Facebook Messenger. Computers & Education, 151 (July), https://www.sciencedirect.com/science/article/pii/S0360131520300622.

Tamayo, P., Herrero, A., Martin, J., Navarro, C., & Tranchez, J. (2020). Design of a Chatbot as a Distance Learning assistant. Open Praxis, 12(1):145–153. Retrieved 01 July 2021, from https://doi.org/10.5944/openpraxis.12.1.1063 UNDP

Tielman, M., Van Meggelen, M., Neerincx, M.A. & Brinkmann, W.P. (2015). An Ontology-based Question System for a Virtual Coach Assisting in Trauma Recollection. In: International Conference on Intelligent Virtual Agents (Springer), pp. 17–27.

Tsai, Chen, J. Y. & Kang, S.-C. (2019). Ask Diana: A Keyword-based Chatbot System for Water-related Disaster Management. Water (Basel), 11(2):234–. https://doi.org/10.3390/w11020234

UNDP, (n.d.). The SDGs in Action, https://www.undp.org/sustainable-development-goals?utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=CENTRAL&c_src=CENTRAL&c_src2=GSR&gclid=EAIaIQobChMIjvGA6sea-AIVvJhmAh2dZghLEAAYAyAAEgLnpfD_BwE

Vilgalys, M. (2018). AI for Citizen Climate Engagement. American Geophysical Union, Fall Meeting, Pub Date: December 2018, https://ui.adsabs.harvard.edu/abs/2018AGUFMED31C1072V/abstract

Wingfield, N. (2017). As Amazon pushes forward with Robots, Workers find New Roles, New York Times (https://www.nytimes.com/2017/09/10/technology/amazon-robots-workers.html).

Winkler, R., & Söllner, M. (2018). Unleashing the Potential of Chatbots in Education: A State-Of-The-Art Analysis. Academy of Management Proceedings, 2018(1), 15903–. Retrieved 01 July 2021, from https://doi.org/10.5465/AMBPP.2018.15903abstract