

PERCEPTIONS ON THE CONCEPTUALIZATION OF A 21ST CENTURY MATHEMATICS INSTRUCTIONAL MODEL

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ABSTRACT

Facilitating learning at all levels of the education stratum to create effective 21st Century knowledge creators, inventors and innovative workers is increasingly recognised today as a primary objective of education. Rapid expansion and availability of knowledge indicates the importance of curriculum and instructions that will empower learners to process knowledge using learner centred strategies. Graduates at every phase of the educational system be armed with the skills to interpret, analyse or manipulate information, critically think about information, ideas and opinions, and be able to draw conclusions, inferences or generalisations, communicate their ideas and provide constructive feedback to peers. The study of 4 teachers and 117 Form Four students at a government secondary school in The Republic of Trinidad and Tobago, was conducted to examine whether elements of 21st century skills, based on the 2T2C model, could be infused simultaneously with the teaching of mathematics. The study applied a quasi-experimental pre-post-tests control group research design. Questionnaires and interviews were completed by teachers and students to determine their perception on the effectiveness of the 2T2C. Students' perceptions indicated that they gained a better perspective and understanding of mathematical concepts through an interactive classroom environment and through real-world questions, applications and projects. Students' communication improved through planned cooperative and collaboration sessions and socialisation using technology software such as wiki and blogs. Students' confidence and self-efficacy improved as they took responsibility for their learning. Initially, some students reacted negatively to the facilitation, citing that they were only interested in passing the examination and that time was wasted learning mathematical concepts. Some students were concerned whether or not the syllabus will be completed prior to their external examination. This paper presents how the 2T2C Model was conceptualized and reports on students' perceptions on the model and how it can be employed in open distance learning environment.

Keywords: 21st century skills, social learning, collaborative strategies, critical thinking, creative thinking, mathematics education, open and distance learning

INTRODUCTION

The advent of institutionalized teaching and learning, along with its critically significant summative examinations, has mainly weakened student's ability to acquire the core 21st Century skills of high-order thinking, communication, creativity and innovation, problem solving and confidence. What is needed is thinking that leads to ideas about problems for which there are no definite or right answers; thinking leading into further enquiry about economic, social, scientific and technological advancements, for which there are a series of alternatives that can be applied or assist in solving some present day dilemma. Learning environments therefore have the opportunity to create a new type of graduate which the 21st Century demands. As such, the goal of this paper is to present a model which will equip and inform educators with some of the skills and competencies needed to create an environment for facilitating learning, where thinking creatively, critically and innovatively, as well as other important skills, are major objectives of 21st century education. The 2T2C Model (Thinking, Technology, Communication and Confidence), has proven to a certain extent that it can aid in transforming classroom settings and assist in improving learners' creative, inventive and innovative thinking, indicative of pedagogy and technologies to accomplish the dissemination of skills and competencies fitted for the 21st Century learner.

In Trinidad and Tobago, the secondary school curriculum is highly developed and the Curriculum Division for secondary school continues to make inputs where necessary to ensure it remains abreast with international standards (Secondary Education Modernization Programme [SEMP], 2002). All cognitive levels as in Bloom's Taxonomy are embedded in the curriculum (Curriculum Division and Planning, 2011). In secondary schools, teachers are continually encouraged to receive teacher training. However, the traditional modality of teacher-centred instruction continues as the major instructional approach. This is due to the summative high-stake assessment which awaits students at the end of secondary school. The key ingredient is not about learning but preparing students to perform successfully at these examinations (Campbell, 1997; Herbert, 2004, De Lisle, Seecharan, & Ayodike, 2010).

The topic of the parent research was therefore chosen in order to present and implement a model which will provide an alternative for the traditional teaching modality, where 'the teacher is the sage on the stage' and predominantly uses the lecture instructional strategy. The use of social and cognitive constructivism forms the theoretical framework. It has become imperative in the 21st century that students be taught or facilitated differently in schools via instructional strategies and techniques (Friedman, 2007). Thus, to determine the effects of the new model from teachers, to simultaneously engage students in the teaching/learning process, is crucial. Open and Distance Learning (ODL) can benefit from the parent study as it uses web 2.0 tools and the components of 2T2C.

THE NEED FOR 21ST CENTURY SKILLS AND COMPETENCIES

Twenty-first century skills include teamwork, communication, innovation, and creativity and have as corollaries, creating, evaluating and analysing, challenging the learner, promoting active participation, argumentation, problem solving, conducting investigations and tackling subject matter that is complex (Assessment & Teaching of 21st Century Skills [ATCS], 2010). It involves a new classroom culture that caters for learners being at the centre of learning and being fully involved in social and collaborative learning. Twenty-first century skills from The Framework for 21st century Learning (Partnership for 21st Century Learning, 2009), transmutes learners into learning applications connected to curriculum content and assessment (Jacobs, 2010). Regan (2008) corroborates that the infusion of 21st century skills must be a primary element of teaching and learning and not placed as add-ons to the curriculum.

Beers (2011) and Greenstein (2012) ask the following questions concerning the importance of 21st century skills: as educators, what do we need to do to prepare our students for the rapidly changing, technology-rich, interconnected global community? What does it mean to be literate in today's world? Can our students question and critically evaluate the information they view? Are they able to work together to solve problems? What do they do when faced with new problems? Are they able to understand and synthesize multiple perspectives?

Friedman (2007) and Wagner (2008) states that employers in the twenty-first century stipulate that employees be critical thinkers, effective collaborators, innovators, and excellent communicators. Bellanca and Brandt (2010) also agrees that twenty-first century companies, organizations and countries are interested in finding the most qualified human capital to contribute to the advancement of knowledge creation. Hence, there is a challenge for educators to transform how they prepare learners for the inevitable and impending workforce.

Schoen and Fusarelli (2008) contends that competencies for the twenty-first century go beyond teacher-centred learning where facts are simply given to students without any collaboration and interaction. They suggest that learning should encompass technological competency, communication and observational skills, analytical reasoning, and adaptability. Spellings (2007) believe that meeting the challenge of a changing world by creating the support structures to infuse twenty-first century skills and guaranteeing that learners have practical problem solving skills is vital to deal with the demands of a changing world. Wagner (2008) further suggests that this separation between what schools are teaching and what students are learning, and what is required for dynamic societal involvement in an ever changing world has created a "global achievement gap". Learning facilitation must therefore simultaneously allow their learners to obtain 21st century skills and competencies while content of the different disciplines are taught.

Educators' goals should thus be to have their learners organize, store, and retrieve knowledge and skills. By applying what we know about how the brain functions and remembers, educators can focus on the learning aspect of the teaching/learning process. All this can only happen if facilitators have the knowledge and experience and use the correct instructional models, strategies and techniques. Instructional strategies and techniques for facilitation must thus be provided to facilitators in order to ensure that they have these skills and competencies. It is thus imperative that a facilitation model for the 21st Century be considered and constructed. This invariably led to the development of 2T2C.

THEORETICAL FRAMEWORK

Constructivist theories stand out clearly as the most suitable to examine the infusion of twenty-first century skills by mathematics teachers of secondary schools. Constructivist theory of learning attributes most of its foundational principles to the works of Piaget (1950) and later Vygotsky (1978). Teachers and learners will be guided via active, collaborative and cooperative measures and strategies to accomplish high-order thinking, confidence, technology competencies, and communication skills, through real-world problem solving tasks, in the form of projects, to attain the skills related to twenty-first century skills and competencies.

Constructivism is a theory with its foundation on observation and scientific study about how humans learn cognitively. It states that people construct their own understanding and knowledge of the world personally and this through experiencing things and reflecting on these experiences (Huitt, 2003). Constructivism as a process of learning can be explained when an individual encounters something new for the first time (Kaur, 2001). This new item

of knowledge first has to be reconciled with previous ideas and experiences, and may change what was believed, or maybe discard the new information as irrelevant. Thus, constructivism involves actively creating our own knowledge by asking questions, and exploring and accessing what we know.

The world does not exist in the classroom alone so it is important that teachers in constructivist classroom use real world problems and applications (Kaur, 2001). This is essential today as the twenty-first century requires graduates to solve new and dynamic problems (Wagner, 2008). Learning therefore is not simply the positive acquisition of facts from one person to another, as a teacher presenting facts to students or a student simply reading and memorizing facts; as in rote learning. Children create new knowledge by thinking physically and intellectually on their actions.

Vygotsky's theory formed the core for social constructivism, which emphasized the importance of social interaction and culture in the construction of knowledge and learning. According to Vygotsky, knowledge and learning are constructed through human interaction with one another. Knowledge is a human product that is socially and culturally constructed (Gredler, 1997). Learning is not simply the assimilation and accommodation of new knowledge but is acquired by actual relationships between learners. Vygotsky proposed that a child's propensity for cognitive growth is bounded on the lower end by the child attempting to learn on his/her own and on the upper end whereby the child learns with the help of persons more knowledgeable, such as a peer, tutor or teacher. Based on Vygotsky belief, that learning is a collaborative process and influenced by culture. He distinguishes two levels of development – the level of *actual development* and *potential development*. Actual development is the level of development that a learner has already obtained and can solve problems independently. The level of *potential development* is the level of development that learners are not capable of doing at the moment but has the potential to do so.

The development of 2T2C took into consideration the need to prepare students for work and/or further studies after secondary school. At the core of the 2T2C model are its four pillars, thinking, technology, communication and confidence. The 21st century requires a different type of graduate who should possess skills to live, function and work in a highly technological and dynamic world. As such, a learning environment that could assist students to acquire 21st century skills, 2T2C was developed.

PURPOSE OF THE STUDY

This study is a derivative of a larger study, and its main goal is to explore the perceptions of the teachers' of the experiment group as they implemented the model 2T2C. The specific research question is: What are students' views of the effects of the instructional model in their learning 21st century skills of thinking, technology, communication and confidence?

METHODOLOGY

Qualitative research design was used in the study whereby two teachers of the experiment group were trained to implement the 2T2C model for nine weeks. Students were interviewed using the one-on-one and focus group approach. Specifically, semi-structured interviews, consisting of a list of open-ended questions was used to determine how students perceive the tenets of the instructional model in terms of acquiring 21st Century Skills and understanding mathematical concepts. The open-ended nature of the questions provided opportunity for the researcher and interviewees to discuss their experiences in greater detail. When the interviewees had difficulties in answering a question or hesitated, the researcher

was able to probe further. Three types of probes were used: detailed-oriented probe, elaboration probe and clarification probe (Barriball & White, 1994). The teachers of the experiment group were asked to assist the researcher in choosing students for the one-on-one interviews and the focus group interviews. According to Creswell (2007) and Morgan (2004), individuals who are not hesitant to speak and share ideas should be chosen over the less articulate and shy, as the latter may present the researcher with a challenge and less than adequate data.

The sample was selected from a total of 50 teachers and 765 students from Waterloo Secondary School (WSS). The sample was then selected from a total of 8 mathematics teachers (from the Mathematics Department) and 117 Form Four students. Four teachers were chosen by the Head of Department based on their eligibility to teach in these forms determined by the Ministry of Education. There are 4 Form Four classes at WSS, namely, Business, Science, General and Modern and the classes met at the same time for the duration of the study. Two teachers were chosen for the control group and two for the experiment group.

TEACHER TRAINING COMPONENT OF 2T2C

The researcher provided the training and support to the teachers of the experiment group in terms of the uses of Web 2.0 tools (technology); enhancing student self-efficacy (confidence); understanding and implementing higher-order thinking skills (thinking); differentiating between high and low order questioning and test items; the correct approaches to having a classroom environment with cooperative and collaborative approaches (communication); and maintaining and sustaining a student-centred classroom environment.

2T2C was used to train the teachers of the experiment group using various teaching modalities as training platforms, which included: face-to-face workshop sessions; use of wiki to place content materials and videos as well as blogs and Skype for asynchronous and synchronous sessions respectively. Face-to-face sessions were conducted to deliver lectures and facilitate question and answer sessions. The teachers have their normal teaching responsibilities during the training period and were not be granted time-off from their employer to participate in the training sessions. In order to expedite the training, weekends and public holidays were utilised. The training of the teachers of 2T2C was completed in 12 weeks. A blended training style was implemented using collaborative and cooperative teaching skills and emphasizing the importance of self-efficacy in problem-solving; high-order thinking skills; communication and social skills for acquisition of knowledge; and ICT competencies. Self-efficacy, collaborative and cooperative, and ICT training was completed in 2 weeks each; while training in high-order thinking is expected took 3 weeks. The final week of training was spent on question and answer sessions.

At a typical session the teachers were given definitions of all the main terms of the training activity, for example, what is confidence and why is it important to the teaching of mathematics, and why must students have confidence and responsibility in their own learning in the 21st century. Many examples were given by the researcher and much discussion was expedited. In some sessions, collaborative and cooperative learning were explained as not merely group work where students are placed in a group and ask to do problems. This was described as a structured activity and many methods were presented such as clusters, round robin, and critical debate, learning cell, fish bowl and think/pair/share collaborative learning techniques. Generally, the objectives, importance, definitions and implementation of the learning activities were facilitated in every session. Articles were provided for further reading and much discussion topics were presented and completed

online. At the face-to-face sessions presentations were done by the teachers concerning what they researched and discovered.

STUDENTS PERCEPTIONS

Focus group interviews by the two teachers were based the following questions which are posted below with general comments and examples of student responses.

Question 1: How would you describe your mathematics experience this term?

All the respondents commented that the term's work in mathematics class was different and that the thinking sessions, with the challenging real-world questions and projects were demanding. Some mentioned that the motivation by their teacher was helpful and the peer-support helped them in understanding the mathematics topics.

"To be honest I do not consider myself a good math student but from the beginning of the class this term, she [Teacher X] motivated me to believe that I can do math and perform well in the class. My marks in the past weren't good but I believe this term it will be better. I give myself a chance now to solve problems that I will not even try before. Math class was real good and yes I appreciated the efforts of her [Teacher X] and my group mates." [EGONE1, recorded November 26th 2013]

"I normally do well in math class Sir [interviewer] and I did not want to miss any math class this term. This should tell you how much more I enjoy doing math now. The real world questions presented a challenge but with the assistance of my friends I was able to help solve them. I never know group work could be so good and rewarding." [EGONE3, recorded November 26th 2013]

"I now understand why we do mathematics in school and I finally got a chance [Opportunity] to use my computer for school work. I cannot wait for next term to reach. Besides struggling with the real-world problems, the class was different. A bit noisy at times but fun with my new group friends – I even made some closer friends from the group work." [EGONE6, recorded November 26th 2013]

"At first I thought that Miss [Teacher X] was not interested in preparing us for our exam [CSEC is the external examination for certification after 5 years of secondary school] but then I understood. I enjoyed the group work and my group [student Smiling]. We did not have sufficient time to use the computer during class time because it [time] went so quickly but we made up outside of class." [EGONE7, recorded November 26th 2013]

Despite most students being interviewed commenting on the various aspects of the classroom sessions, most of them had concerns about if they were being prepared and will be ready for their CSEC assessment at the end of their tenure in the upper school. Some students iterated that:

"I was enjoying myself so much that I asked Teacher X what about preparing for CXC [CSEC examination]. I wanted to know if I will be ready for CXC. Preparing for CXC is important and I just wanted to know that at the end I will be fully ready... my teacher gave me the assurance though that I will be." [EGONE5, recorded November 26th 2013]

"...my concern was if I was being made ready for CXC. I just wanted to know that the problems were similar to what will be asked for CXC. I was told by Sir [Teacher Y] that I will

be ready and that I should not worry. At some occasion Sir [Teacher Y] had to stop the class and explain to assure us.” [EGONE2, recorded November 26th 2013]

Question 2: What did you enjoyed most about the activities in your mathematics class this term?

The students responses were varied but centred on the active classroom environment facilities used and the teaching model employed. The students all noted that the collaborative atmosphere and the real-world challenging questions were at the forefront of their responses. In describing what was most enjoyable and different about the term’s work this is what some of the interviewee stated:

“The sessions were generally good and it did help me to be more motivated. I am motivated already and the earliest sessions prepared me for what was to come. I loved the group work in that I was allowed to think by myself and then share with my group members. The fact that I was given the chance to think was special. And the use of the computer to communicate with my group members outside of class solving problems was nice. The questions were challenging and kept my group busy throughout the term, in and out of class.” [EGONE4, recorded November 26th 2013]

“For me the group work was really worth the while as it helps me understand the work better sharing with my group friends. Not only did we communicate on the wiki and by using the blogging feature, we also used Facebook and Skype to keep in touch and share. The questions were very challenging so having group members help was a plus, as together we eventually work out most of the problems.” [EGONE2, recorded November 26th 2013]

“What I enjoyed most was being able to work challenging questions out like never before. At first I was not sure [about solving the real-world problems] but as the class continue I was able to give it a shot [try] and was able to solve some problems; with my friends and of course by myself. And let me add also that the use of the computer to add sharing was nice ... I had some issues with one or two of my group friends at first but afterwards things went well... maybe it was the work we all had to do” [EGONE1, recorded November 26th 2013]

Question 3: What are your views of the computer sessions as it pertains to you learning mathematics this term?

Most of the students hinted that the computer sessions in the computer laboratory were helpful as it reiterated that there was so much information on the internet and that the wikis and blogs allowed them to put the pieces together as a group to solve the project problems. Some however saw the sessions in class as non-productive as the internet access was too slow. They however valued the use and purpose of wikis and blogs as presented by their teachers. Some students commented that the technology sessions were good because it took them out of the normal classroom session and use a resource which they were accustomed too.

“...despite the internet being slow, the usefulness of the wiki seem to be something we can use. Also the change of classroom is good and using the computer is also a plus and a joy to us.” [EGONE3, recorded November 26th 2013]

“...to have mathematics classes in the computer room is fun. The internet gave some trouble because it was slow today but we did learn something new, which we can try at home and use to be connected with our group members.” [EGONE6, recorded November 26th 2013]

Question 4: What do you think about the real-world questions presented this term in mathematics class?

All the students commented that the real-world problems were challenging and made them think more than they ever had to think before in any mathematics class. They also said that they were happy that they had the group to assist them. In the end, most of them said that the thinking cause them to see the relevance of real-world questions. Some said that their teachers' portrayal of the need to solve problems that were not linear or non-algorithmic was well received as they saw the need for doing so.

"I understand the relationship between mathematics and real-world problems. I find myself looking to working-out [solving] problems of every day by myself and with my friends out of class – my parents were even surprised. I actually surprise myself by continuing to relate math with my house work." [EGONE4, recorded November 26th 2013]

"I never thought that this [mathematics] was so important and well, relevant. It's like it is found everywhere and in everything. I know now that math is used to solve traffic issues and other social problems. This was new to me and my friends and I talk about it all the time... now that I know why I am doing math, it have brought new meaning to this and other subjects... so school is not just about learning for learning sake..." [EGONE7, recorded November 26th 2013]

Question 5: What are your views on the collaborative sessions of mathematics class this term?

Most of the students agreed that the collaborative activities were different and well-structured from other group work which they encountered in the past. The "think-pair-share" method of performing group work was one of the procedures most referenced and most saw it as a novel and outstanding experience.

"...I like the think and the pair part of the group work as it was different and made me really think to have something to share with my pair [pair colleague]
I actually got the opportunity to quietly think and share what I think in a math class and my group was serious to the job [of solving the problems]" [EGONE6, recorded November 26th 2013]

"I hope that this method [think-pair-share] can be done in all my classes. I gained a whole lot from this and I tried this with my brothers at home and other friends." [EGONE2, recorded November 26th 2013]

The students also seem to suggest that the teacher's control of the classes during the group activities was manageable and accounted for the "think-pair-share" method to be a success.

"...although there was some noise at times in the class during group work it [the noise] did not stop us from learning and thinking and sharing too. The class space was good also for the group work and I learned a great deal." [EGONE4, recorded November 26th 2013]

"... the classroom group work was well participated by most although some wanted to work by themselves. Teacher X had some problems at the beginning of the term but as the term went on all [students] participated." [EGONE5, recorded November 26th 2013]

Student responses from both the General and Business Groups suggested that they were able to participate more in class and be a part of the collaboration in the class and the learning experiences. They also suggested that this participation accounted for them solving

more problems. The teachers prompted them to answer the questions and never gave them the answers to problems unless they tried by themselves and with members of their groups. Some of the students hinted that during the term their teacher had to talk to some of their colleagues about the need and importance of collaborative activities

Question 6: Do you think that you have the skills to solve or attempt to solve real-world mathematics problems?

Most students understood the process involved. Some suggested that they are in a better position to attempt to solve any mathematics problem; others said that they are gaining the confidence to believe they can solve any mathematics question presented; yet others stated that they are still a bit pensive and that the class this term was very encouraging in this regard. One student stated that there were doubts but additional time could help to gain the confidence required.

“... my fear for solving math problems is almost gone and ... I feel much better now. I have change how I think about math.” [EGONE2, recorded November 26th 2013]

“... I have the skills but still a bit doubtful...I will get there shortly but I need to practice more and think more.” [EGONE5, recorded November 26th 2013]

“... I have it [the skills] and I have worked out more problems this term.” [EGONE4, recorded November 26th 2013]

Some of the students mentioned that the teacher’s probing and questioning also accounted for them to think more about a solution. Their teachers allowed them the space and time to think through the problems. They further stated that the real-world questions and projects assisted them to see the need for mathematics.

Question 7: What did you gain from the classroom interaction during mathematics classes?

The students interviewed said that they welcomed and enjoyed the interactions. They mentioned that their teachers explanation of the need to acquire communication skills through collaboration were helpful. Despite not being on friendly terms with every member of the class, students suggested and emphasized that the professional nature of the group work was pleasantly surprising. There is the question whether all this group work would prepare them for CSEC examination.

“... it was a nice sight to see my friends in the class trying to work out a problem and then share what they think is the answer based on their reasoning.” [EGONE2, recorded November 26th 2013]

“... because there was so much sharing in my group there was hardly [any] need for the teacher at times.” [EGONE7, recorded November 26th 2013]

“... I can communicate with anyone now to solve problems – a really nice experience ... I liked it when the group came together and we all put in our little pieces to help [solve the problem] ... a really nice experience but I wondered if it will help me in exams.” [EGONE6, recorded November 26th 2013]

Most students suggested that the mathematics classroom sessions were different and the inclusion of collaboration on the computer on the wiki and via blogging added to the interesting nature of this term’s mathematics experiences. They also suggested that

continuing the discussion online was a great move because classroom time was not sufficient when they started sharing ideas to solve the problems given.

“... to have the class extended was really nice and then to use the computer was even better... as the class-time was not enough it was nice to have the internet to continue our discussions to solve the challenging problems... blogging was like Facebook minus the distractions.” [EGONE1, recorded November 26th 2013]

RESULTS AND DISCUSSION

In this study, the exploration of teachers' perceptions of implementing a newly designed instructional model, 2T2C, was deliberated. As with any reform process, the execution of a new model is compared and shaped by ones existing beliefs and practices. It was clear from their responses that although some were concerned with being prepared for CSEC, most enjoyed the challenges and appreciated the real-world problems and the group work. Most admitted that their confidence improved. Despite how arduous and tough a problem may seem, they were willing to attempt to solve it. Some concurred that the technology assisted them with their work as the wiki platform kept them, and their classmates connected and sharing. Generally, most students benefitted from the experience positively.

The students of the experiment group also stated that their collaborative skills improved from the sharing in the group work activities. The lecture and video sessions on confidence that engaged the students throughout the study was very rewarding to most students. Some students said that they felt better prepared to not only solve mathematics problems in class but real-world and real-life problems and issues they encountered daily. These student responses about their experiences of the implementation of 2T2C suggests 2T2C may be used in any other teaching disciplines, platforms and modalities. What is important is that teachers must be trained to implement 2T2C. Though more time planning creative lessons is required in implementing 2T2C, the outcome is an active classroom environment with learners having 21st century skills and competencies which are necessary for future studies and the present and future dynamic workforce (Friedman, 2007; Wagner, 2008).

CONCLUSION

Education institutions are primarily impeached with major responsibilities of harnessing their learners with the necessary skills to be successful practitioners in the future. The framework of The Partnership for 21st Century Skills (2005) addresses the needs of this changing world and developed its structure based on presumed future economic needs. ODL institutions and those harnessing ODL as additions, need to be efficacious and revolutionary in preparing their learners for the world that awaits them. The implementation of 2T2C can assist ODL in that it simultaneously infuses 21st Century skills and competencies while content is being facilitated. The 2T2C Model is an avenue where not only secondary school classrooms of all disciplines can benefit, but with huge potential in ODL environments. The models' underlying principles can ensure the creation of a vibrant, effective and efficient setting in ODL to attain 21st Century goals. The tenets of 2T2C, Thinking, Technology, Collaboration and Confidence, can be achieved in any student-centred, active and interactive classroom, and ODL's sites and scenarios, with its natural interactive dimensions is ideal for employing 2T2C.

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