

Investigating the Deployment of Serious Games in Secondary Education: A Pilot Study Inspired by Design-Based Research

Jeffrey Earp^{1(✉)}, Chiara Eva Catalano², and Michela Mortara²

¹ Istituto per le Tecnologie Didattiche, CNR Via de Marini 6, 16149 Genoa, Italy
jeffrey.earp@itd.cnr.it

² Istituto di Matematica Applicata e Tecnologie Informatiche,
CNR Via de Marini 6, 16149 Genoa, Italy
{chiara,michela}@ge.imati.cnr.it

Abstract. This paper describes a pilot deployment in lower secondary school of a serious game dedicated to the learning of history. The primary aim of the initiative was to investigate the integration of Serious Games-based learning environments in the school study of humanities subjects. The pilot was carried out as part of investigations that researchers in the Games and Learning Alliance (GALA) Network of Excellence are conducting into the adoption and deployment of Serious Games (SG) in formal learning contexts. In this regard, the paper outlines the sequence of deployed pilot activities, which was shaped with the intention of responding to the needs of all the participants involved – researchers, educators and learners. This approach is inspired by the principles of design-based research, as illustrated in the strategies adopted both for piloting activities and data gathering. The paper reports the outcome of these and considers some implications of the adopted approach both for SG deployment in formal education and for implementation of experimental SG pilots of this kind.

Keywords: Serious games · Game-Based learning · Experimental pilot · Design-Based research

1 Introduction

The widespread integration of serious gaming is looked on by many as a promising path towards more effective learning in formal education contexts, and as a means for instilling and consolidating technology-enhanced innovation, especially within school contexts. In this light, increasing attention is being focused on the drivers and obstacles to such integration, especially with regard to curriculum [1] and to pedagogy and praxis [2]. Moreover, a clear need has emerged for evidence-based research to support policy-level efforts towards integration [3]. These aspects are currently the subject of investigation by researchers in the Game and Learning Alliance (GALA)

Network of Excellence¹, who are exploring ways to foster wider and more effective use of Serious Games (SG) in formal learning contexts.

The research activities reported in this paper were carried out as part of that effort. They concern the pilot deployment of a SG dedicated to the study of history by students in primary and lower secondary school. As well as investigating the educational efficacy of the SG as the core component within a technology-enhanced learning environment, the pilot examined key issues in the deployment of serious games in school education such as integration in the organisational and educational praxis followed in schools, the design and orchestration of game based learning activities, and the teacher's pivotal role in leveraging the educational potential that SGs offer.

The following section begins by describing the key elements involved in the experience, namely the SG and the experimental context for the deployment. It then focuses on the sequence of activities undertaken, explaining the rationale underpinning the design of the sequence and, more generally, of the pilot SG implementation as a whole. This is illustrated through description of the activities, their implementation and outcomes. Finally, some considerations are provided about the implications of the adopted approach, both for SG deployment in formal education and for the implementation of experimental SG pilots of this kind.

2 Pilot Design and Preparation

2.1 The Adopted Serious Game

The game adopted for this pilot is “The Plague”, the first title in a series of three SG called “Playing History” produced and published by Serious Games Interactive². The Plague is a narrative-based game that gives youngsters between the ages of eight and thirteen the opportunity to experience and learn about a key event in European history, namely the plague epidemic that struck Europe in the Middle Ages. The game is set in Florence in 1348 during the Black Death. The player takes the role of a young boy whose family is threatened by the disease and who must discover a way to protect them from the rapidly worsening epidemic. The central game mission is to gather key information that could help the family avoid the advancing ravages of the plague. This is done by interacting with Non-Player Characters (NPC) and following the clues they give to complete a sequence of tasks. In this manner, the player unlocks vital information for deciding what course of action to take in the game to avoid the family's contagion. The game also features a parallel treasure hunt for historically inappropriate artefacts “hidden” throughout the environment (a PC, antibiotics, etc.). Each of these embeds information or powers that are useful for progress in gameplay. The player can also earn extra points and status by playing embedded mini-games, some of which are also learning opportunities.

The game primarily targets the acquisition of knowledge about the Black Death and awareness of its impact on medieval society. This mainly occurs through the

¹ <http://www.galanoe.eu/>.

² <http://playinghistory.eu/front>.

unfolding of the central narrative/mission, but also via the artefact hunt and mini-games. Immersion in and exploration of the gameplay setting also contributes to the learning experience by conveying a sense of medieval life generally: the behaviour and beliefs of ordinary people, the role of faith and religion, the nature of medical and scientific knowledge and practice, types of economic activity, etc. Of course, the representation is suitably stylised for youngsters, dealing as it does with a dark and gruesome period in human history.

To facilitate use in a school setting, the digital game comes with a supplementary educational package that includes student and teacher guides, summative evaluation tests, and activity sheets for further studies.

2.2 Deployment Setting

The pilot was carried out in 2013 at an international school in Italy where the lower-secondary grades follow the International Baccalaureate Middle Years Programme and the official teaching language is English. This choice ensured that the participating students possessed the English language skills demanded to play the game. The socio-economic background of the students is generally higher than average.

Thirty-five students aged 12–13 from two Year Seven classes took part in the pilot; preparation for final exams prevented more extensive participation. Both classes were taught by the same history teacher, who had no previous experience with game-based learning. The year before the pilot was run, most of the students had briefly studied the Great Plague of London (1665–1666) as part of their history course with the same teacher. For this reason, the chosen SG was considered to fit closely with curriculum objectives, even if the students were at the upper limit of the game's target age range.

2.3 Design of the Pilot Activity Sequence

A central aim of this research initiative was to investigate issues surrounding the deployment of serious games in formal education. So, as well as ascertaining the nature and degree of generated learning, interest also centred on the design, implementation and effectiveness of the classroom activity sequence intended as a pilot educational intervention.

Given this focus, particular importance was placed on recognition of, and respect for, the intertwined-but-distinct needs of all the pilot participants - researchers, educators and learners. Accordingly, an explicit effort was made to design and implement a sequence of pilot activities that reconciled the researcher's data gathering requirements with the teacher's (and students') need - and right - to a fruitful and engaging educational experience supporting the attainment of expected learning outcomes.

This consideration is one of guiding principles of Design-Based Research (DBR), an approach adopted in educational research that acknowledges the intrinsic complexities and ethical responsibilities involved when pilots are run in real school environments [4]. Furthermore, DBR recognises that piloting educational innovations for research purposes means "engineering" a "working" instance of the self-same innovation within experimental settings that have been shaped, explicitly or implicitly, to a greater or lesser

extent, to fit the specific research agenda [5]. DBR proponents in the game-based learning field [6] concur that “the enacted intervention is a dependent, not an independent, variable” [7] and indeed, “...the intervention (itself) is the outcome.” [4]. This, and the many other variables at play in real educational environments, place limitations and strains on quasi-experimental research methods, particularly with respect to assessment of learning gains through pre- and post-testing - the prevailing strategy adopted in educational (and game based learning) research [8–10]. While DBR does not eschew quantitative methods altogether, as is the case in the pilot study reported here, it stresses the need for careful attention in experimental design and, especially, recognition of the agendas that the design embeds.

Bearing this in mind, the activity sequence in this pilot was designed and implemented through researcher-teacher collaboration with the express intent of reconciling the respective agendas as far as possible. For example, limited student access (a common constraint in school-based pilots) restricted the scope for administering questionnaires, interviews etc. So activities were designed to be meaningful and engaging for students, educationally fruitful and pedagogically sound for the teacher, and of a kind yielding useful data for the researcher (overhaul of the server-end SG management application posed some doubt about the ultimate availability of analytics data from the pilot). Accordingly, the following pilot phases were designed.

Preparation. To begin, a structured interview was conducted with the teacher using a question matrix specifically designed for use with practitioners approaching game based learning for the first time [11]. The intention was to elicit the teacher’s expectations, plans and ideas about the intervention, to raise awareness of critical aspects involved in implementing and orchestrating GBL activities, to establish the basis for teacher/researcher understanding, and to benchmark attitudes for evaluation purposes. A follow-up structured interview was conducted in which the question matrix responses given at the outset were reviewed and reappraised in the light of the experience (see below).

Subsequently, a unit of learning was developed with the aid of an online pedagogical planning tool developed at ITD-CNR and customised for supporting the design of game-based learning interventions [12].

Classroom Activities. Both classes took part in three 120-150 min sessions held over a period of three weeks. The sequence was fashioned to fit the standard briefing/gameplay/debriefing structure but, as outlined above, was conceived especially to meet both research and educational objectives.

- Session 1: introduction; pre-test of domain knowledge; co-construction of a mind map about the plague; group-based paper & pen designs of a digital game on the plague; introduction to the SG.
- Session 2: gameplay with SG in computer lab (2 players per PC) monitored by research team (three student pairs per researcher).
- Session 3 – post-test; review and updating of session 1 mind map; integration of “favourite” SG aspects in groups’ game designs; class-based listing of desired modifications to the SG for a new 2.0 version of the game.

Teacher Briefing & Debriefing. The pre-pilot questionnaire revealed that the teacher largely foresaw the experience as an opportunity to innovate and diversify her teaching practice, aligning this with demands for digitally oriented school preparation, and to enhance student engagement by stimulating their imagination. From the pedagogical viewpoint, she foresaw a chance for task-based learning that leverages the educational affordances of multimodality. She considered the chosen game to be a good match with the teaching curriculum but nonetheless expressed concerns about how the experience would be accepted by students and parents alike; her own inexperience with GBL was also an issue.

After the pilot the teacher confirmed most of these initial thoughts. She expressed satisfaction with learning outcomes (especially consolidation of domain knowledge), the level of student acceptance/engagement, and their willingness and capacity to collaborate, something she had not foreseen. She would have preferred the SG to be more graphic, challenging and content-rich. She evaluated the design of the activity sequence positively, particularly the “supplementary” briefing/debriefing activities (listed above), and appreciated the benefits of the design effort. This was especially true given the technological and classroom management challenges she saw such sequences as posing, something that was facilitated in this case by teacher-research co-presence. In retrospect, she would have included an out-of-class phase and she thought mind-mapping would be more fruitful if a group-based phase were added to the plenary work (see Sect. 3).

3 Pilot Implementation & Outcomes

3.1 Benchmarking Knowledge & Assessing Learning Outcomes

Two different strategies were adopted for benchmarking students’ entry-level domain knowledge and assessing their knowledge acquisition: standard pre-and post-testing and an experimental mind-mapping activity. Both are reported here, with a twofold aim: firstly to give a general picture of learning outcomes resulting from the pilot; secondly, to examine whether and how the deployed activity sequence might meet educational needs and, at the same time, generate useful research data.

Pre- and Post-testing. This activity was carried out using an adapted version of the 21-question multiple-choice quiz contained in the game’s resource pack for educators. Thirty-one out of the 35 participating students completed both tests. Their results are briefly outlined below to give a general idea of learning outcomes; a more detailed statistical analysis is to be reported elsewhere.

Figure 1 above shows individual students’ pre-test (dark-coloured bars) and post-test results (light-coloured bars), arranged according to the latter. For reference, the academic pass mark of 50 % (10.5 out of 21) is indicated by the dotted line. In the pre-test, the mean score (dashed line) is 13.6 out of 21 (64.8 %), with 28 out of the 31 students (90 %) achieving a pass (dark-coloured bars above dotted line). By comparison, the mean score in the post-test (dot-dashed line) rose to 15.9 out of 21 (75.7 %), and all but one of the 31 learners (97 %) achieved a pass (light-coloured bars above dotted line). Looking

at students' progress individually, we see that 28 (90 % of the total) improved on their pre-test score, eight (26 %) doing so by a margin of 25 % or more. Conversely, three (9.7 %) actually regressed, by margins of 11.1 %, 12.5 % and 35.7 % respectively. Despite this, the outcome can be deemed positive, generally speaking, especially as pre-test results indicate domain knowledge was already relatively solid.

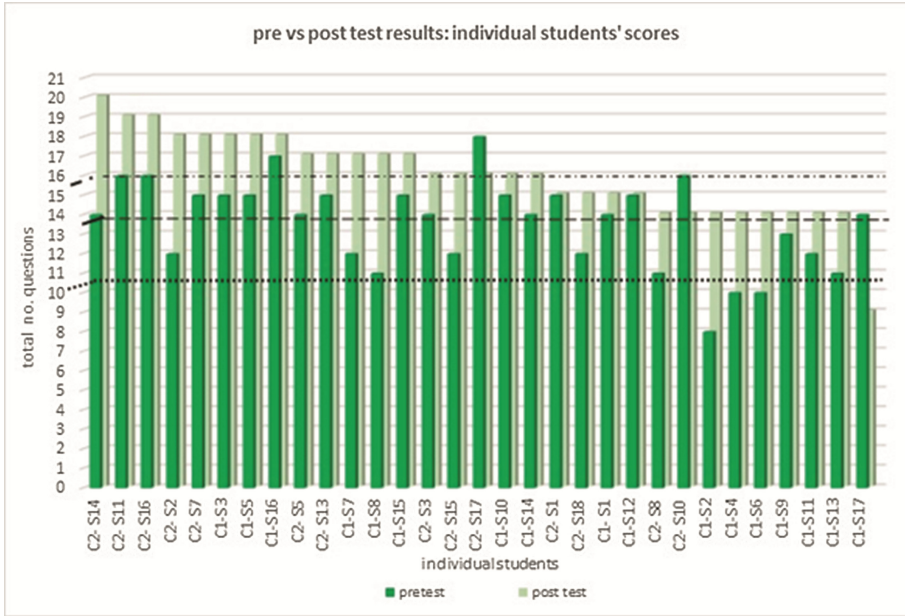


Fig. 1. Total number of correct answers given by each student in pre- and post-tests (Color figure online)

Figure 2 above compares the total number of correct answers generated for each question in the pre- and post-tests, with results arranged according to post-test outcome (light-coloured bars). Looking across the test, we see a cluster of four questions (Q19, Q04, Q18, Q11) that generated distinctly more errors than the remainder, especially in the pre-test. Comparison of total pre- and post-test scores (dark vs light bars) reveals a mean increase in correct answers (learning gains) per question of 3.5 (11.3 %). Four questions generated particularly strong gains: two of the above-mentioned initially “difficult” questions – Q19 (73.3 %) and Q04 (50 %) – together with Q20 (51.7 %) and Q05 (31.8 %). These four questions all deal with information that is mission-critical in the game. By contrast, one question - Q06 - actually generated a net *decrease* in students' correct answers in pre- vs post-testing (-10.3 %). In this case, the related information only emerged incidentally to gameplay (mentioned in passing in a branching dialogue with a NPC). So some players may well have missed it or paid it little heed. What's more, all those who got Q06 wrong (16.1 %) did so by choosing an option (high food prices caused by a ban on peasants entering towns) that, in the context of gameplay, is ostensibly plausible; the player has to sneak past guards to pass the town gate. So the

game narrative may have confused some players on this aspect, especially those who were less attentive to the domain content presented in the series of branching dialogues.

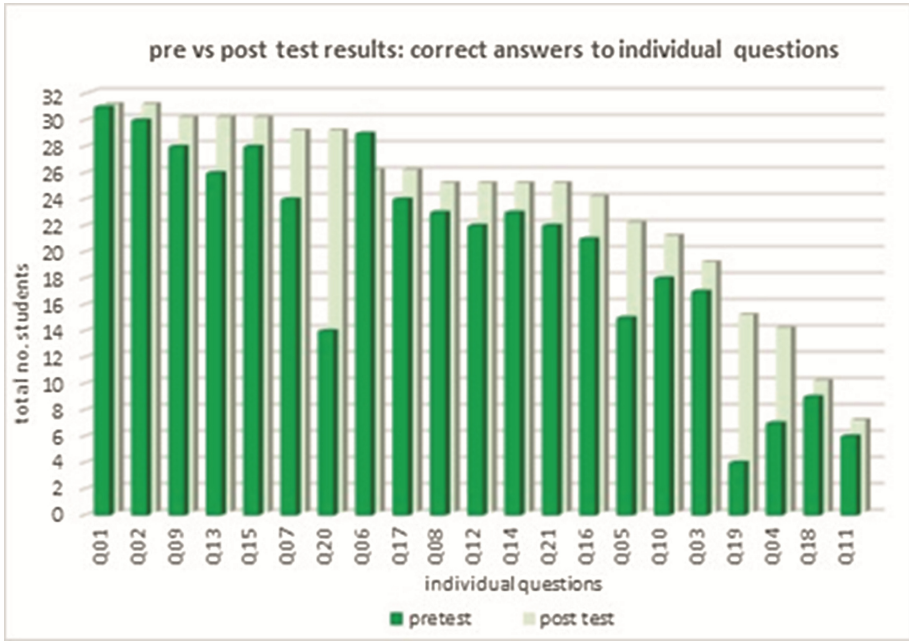


Fig. 2. Total of correct answers to individual questions in pre- and post-tests (Color figure online)

3.2 Joint Mind Mapping

As mentioned in Sect. 2, the application of quasi-experimental research methods in real learning contexts is subject to various limitations, especially in gauging learning outcomes. With these and context-specific educational needs in mind, an experimental strategy based on mind mapping was devised and implemented. The aim was to gather useful data on learners' domain knowledge within an activity that makes an educationally meaningful contribution to the pilot activity sequence (and to the learning process), rather than simply interrupting it or, at worse, undermining it.

Pre-existing knowledge was captured in whole-class, on-the-fly construction of a digital mind map that established “what we already know” vs. “what we need to find out” in a tangible, jointly-owned construct [13–15]. After gameplay, the map was re-presented for the class to clarify, correct and expand through integration of their new knowledge. The final map thus represented a (mediated) measure and embodiment of their collective learning; it is also a testament to – and fruit of – their collective progress. In this manner, the assessment process (and the overall pilot) acquire greater intrinsic meaning for students and teachers. Usually, pre and post-test results, along with other data, are the exclusive preserve of the researchers, indicating that members of the

learning community are treated purely as experimental “subjects”, even outside the strict confines of Randomised Controlled Trials [16].

Pre-game mapping generated a substantial body of generally accurate and detailed information that was almost perfectly balanced across the two classes (54 and 56 concepts respectively), in part due to the uniformity of time allocated (20 min). Surprisingly, only a few of the 110 items appear to have been drawn directly from the contents of the pre-test, even though the concept map activity was run immediately after the test.

The classes’ contribution to the postgame mapping was starkly different. The first class made 21 changes to their original map, 17 integrations of information gleaned from the game, two manifestly gained from external sources (indicating some self-guided study), and two regarding unconfirmed information “suspended” in the original map. By contrast, the second class made only six changes: three game-based integrations, two from external sources, and one item expressing a reflection spurred by both the original map and the game. This considerably weaker response was not a reflection of lesser ability or lower engagement in pilot activities; indeed monitoring and data analysis suggested this class was actually stronger in both cases. Rather, the cause almost certainly lies with contextual factors: their debriefing session was held on the second last (and extremely hot) day of the school year, when enthusiasm and attention levels were at a very low ebb. It is reasonable to suppose that more felicitous timetabling would have produced a stronger response for this class.

3.3 Reflections on the Two Approaches

The mapping activity generated a largely positive response from students, who participated actively and enthusiastically. The quantity and accuracy of information gleaned from gameplay, especially by one class, were a good indication of knowledge acquisition and appeared to confirm the test results reported in Sect. 3.1.

That said, some caveats apply to the results obtained from both strategies. The pupils had already studied the topic somewhat the previous year, so a focused intervention of any kind was bound to reactivate “submerged” knowledge to some extent. In addition, the demands posed by school timetabling placed limits on the scheduling of the class sessions in the pilot sequence and so timing of the respective activities was far from optimal, as mentioned.

During joint mind mapping, efforts were made to elicit responses from as many students as possible and teacher/researcher intervention was deliberately kept to a minimum. However, it should be recognised that the outcomes reflect a collective effort, are shaped to some extent by class dynamics, and inevitably involve some degree of meditation. By the same token, active, student-centred information encoding in mind mapping presents advantages over decoding of a narrow set of options in multiple-choice tests. This is certainly the case from the educational viewpoint, both for formative/diagnostic assessment prior to gameplay and summative post-game evaluation. From the research angle, mind mapping is certainly subject to contextual factors but avoids the clouding of results often caused when students apply guesswork and/or deduction strategies in answering multiple choice tests.

Mind mapping was singled out in teacher debriefing as having been particularly successful. It was agreed that its effectiveness would be increased if mapping were first

carried out in small groups, whose maps would subsequently be merged through plenary negotiation. It was also agreed that running both mapping and pre- and post-testing generates a fairly high cognitive load and could pose a problem of cross-contamination, although there was very little sign of this happening in the pilot.

3.4 Brainstorming a Plague Game Design

The activity sequence foresaw a further activity in which the students worked in teams with paper and pen to brainstorm an imaginary digital game on the plague. This activity was implemented in two phases: game design in the briefing session, before gaining any notion at all of the SG; modification of the original designs in the debriefing session after having played the game. Phase One was a chance to re-engage the class after the pre-testing, to gain some insights into their attitudes to - and experience with - digital games, and to gauge expectations about the SG. Phase Two provided a meaningful, student-centred basis for expressing positive reactions to the SG. Negative feedback was gathered in a supplementary step, described later in the paper.

In the briefing session, self-formed teams comprising 3-5 students had about 20 min to imagine and devise a digital game on the plague. To help them, they had a worksheet with five headings that they were to expound on with descriptive text, brief points or illustrations, as they preferred. These headings were:

- setting (real or fantastic, in any time)
- plot (rough storyline)
- characters (invented or borrowed)
- gameplay (object of the game, rules, mechanics, interaction, etc.)
- “must-haves” (at least three elements considered indispensable to the game)

At the conclusion of that first phase, a representative from each team presented their game design to the whole class.

In phase two after SG gameplay, the students were asked to consider incorporating a maximum of three aspects gleaned from the SG that they wanted to include in their own game design; no minimum threshold was set. The assumption was that, given the students would likely invest a sense of identity and ownership in their designs; they would only choose elements from the SG that they genuinely valued. From a research perspective, this had the advantage of not having to prompt the students about what aspects in the SG to evaluate. Additionally, the students had to negotiate and rank the relative merits of their feedback suggestions on their own terms and mindful of the consequences, rather than being tempted simply to gratify the adults with positive numerical scores.

Outcome of Game Design. All ten teams in the classes collaborated closely on their game design and practically all the students were motivated and engaged. Group discussion was intense: most individuals vigorously advocated their ideas, and proposals were strongly contended before acceptance, rejection or compromise. The students clearly invested value in their team products, as demonstrated by general eagerness to share ideas with the adults and, in some cases, with other teams. This was also evident in the

attentiveness and mutual encouragement shown when the various designs were presented to the whole class at the conclusion of phase one.

Overall, the first-round designs reflected enthusiasm, thoughtfulness and creativity. Familiarity with digital games was evident, especially among the boys. Some interesting parallels with the SG emerged, including one design for a plague-themed serious game and two designs sharing exactly the same setting as that in the SG.

Phase two also proved to be engaging. Group participation was strong and discussions were earnest: all the groups managed to identify three features without any trouble and only one of the thirty proposals was insignificant. Analysis of the responses revealed that 57 % regarded more entertainment-oriented features, such as amusing characters and fun mini-games, while the other 43 % were more closely aligned to game mechanics and disciplinary content. This fairly even split is interesting given the young age of the user group, and also in view of the oft-expressed need to reconcile and balance game and educational factors goal in SG design.

Negative feedback was gathered by asking the classes to provide concrete suggestions for a revised version of the SG and for new titles in the same series. The rationale was that framing criticism as inherently constructive and valuable would limit stigma and encourage the students to speak freely. This was organised as a plenary class discussion, with spontaneous proposals being briefly discussed and then put to a (non-compulsory) show-of-hands vote. Although subject to peer pressure, the voting step was considered useful for both engagement and motivation. The ideas attracting strongest consensus indicate that, overall, the students would have liked a more dynamic, engaging game experience with a richer content base. This is understandable given that the students are at the very top of the SG's target age range.

4 Conclusions

This paper has examined a pilot deployment of a serious game in formal education that was intended to pursue both research and educational objectives. The author has proposed an approach to serious game piloting that draws inspiration from the principles of Design-Based Research. These were adopted in the pilot design in an attempt to address some fundamental issues arising from enactment of experimental activities in formal education contexts. Among these are the inevitable bias resulting from implicit embodiment of the researcher's agenda in pilot design and deployment, limitations in applying quasi-experimental research methods to game-based learning pilots enacted in "real-world" contexts, reliance on pre- and post-test results alone to substantiate learning outcomes, and making due allowance for the need of teachers and students to pursue educational objectives while engaging in research undertakings.

Results from the pilot implementation, although limited in scale, are encouraging. Enactment of the activity sequence designed to meet various piloting needs yielded generally positive results. These indicate that further investigation is warranted. In particular, more extensive field testing of the strategies and activities outlined in this contribution would help to substantiate their validity and applicability on a wider scale.

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