A Spiral Software Engineering Model to Inspire Innovation and Creativity of University Students

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Abstract—University students have tremendous energy that could be utilized to support their universities' visions and their societies. However, students face several problems to convert their innovative ideas into actionable projects. The problems are related to their personalities, monetary support, environment, and lack of mentoring. An innovative idea goes several steps to crystallize, develop, and then be evaluated to gain success. However, the innovation process is agile, unstable, and subject to the risk of failure. The spiral software engineering model is a development model for risky agile projects. Therefore, this paper proposes an iSpiral (innovative Sprial) model based on the original spiral software model. The iSpiral model starts with student ideas and ends with creative operational projects. The proposed model helps to mentor students' initiatives qualitatively over time. Compared with related innovative models over eight criteria extracted from the literature, the proposed model was found actionable and easy to use. The proposed iSpiral model was applied to a series of interrelated student ideas, switched unmanaged and risky initiatives into active-inspired projects.

Keywords—Spiral Model, Innovation, Creativity, Software Engineering, Mentoring

1 Introduction

Creativity and innovation apply knowledge and cognitive skills to generate products, services, and knowledge; therefore, innovation is considered as the heart of knowledge management [1]. According to Panagiotis and Berki, creative thinking is defined as "the thinking that enables students to apply their imagination to generating ideas, questions, and hypotheses, experimenting with alternatives and to evaluating their own and their peers' ideas, final products and processes." [2, p. 6].

Innovation strategies stimulate innovation by a set of guidelines or by sharing experience from previous inventors [3]. Producing an innovative idea is unsystematic extraordinary process; therefore, creativity cannot be formalized or easily customized, especially for students in universities. In a university environment and regardless of student specialization, a student needs to empower his academic skills online with the market and improve his nonacademic skills with peers to prove himself. One primary objective of a student is to serve his society and develop new solutions to face arising problems around him. Free extracurricular ideas make controlling and following student ideas cost and time-consuming. However, merging the ideas of creative students from more than faculty could increase creatively and collaboration [4]. Since informatics systems have cognitive and social aspects, it is a potential space for creative students[5]. Therefore, mentoring and discovering and enhancing creative students are challenging.

Burner argued that students could understand topics no matter how they are complex using a well-controlled education progresses[6]. Bruner’s spiral curriculum key features include student progressively elaborating topics, increase topic complexity that each student topic revisit; thereby building new learning based on the relationship with old learning[7].

The significant problems of innovations produced by students are build costs, risk of failure during ideas incubation, and potential scope creeps. Without mentoring and controlling the students’ projects, they may end up with a failure. Such failures are due to their lack of experience, lack of mentoring, and the student personnel who are willing to change indefinitely. The decision of practices that a student can engage depends on a two-way diffusion process with their instructors [8]. The process of measuring and validating students’ innovation capacities are challenging, and in many cases, is affected by student higher education and related entrepreneurship [9]. Although pedagogical activities that include a creative component could encourage creativity and critical thinking of students[10], social aspects are not well covered at the same time.

Therefore, this paper proposes to adopt and modify the Boehm spiral model [11] to a new model called iSpiral (innovative spiral model) to overcome the research problem. Technically the Boehm spiral model is devoted to software development; however, this paper applies it to an agile operational environment in anonymous university. The spiral model works in iterations. First, the mission and objectives of the university are explained to students, followed by a series of entrepreneurship and innovation workshops and events that booms students’ minds. At the same time, risks, and mitigation plans are developed accordingly to make sure that ideas, resources, and tools are appropriate and sufficient. Then when a new idea is triggered in the student mind, immediately it gets saved in a system, other peers and collaborators discuss further, and a new solution is developed. The solution is tested and reviewed, and a new iteration is planned. Although the adopted Boehm model may seem similar to Bruner’s model [6], the Boehm model was designed to foster additional factors of risk and budget that need to be managed instantly. Moreover, the Boehm model links the objectives to the project outcomes.

The primary research objective is to collect, manage, collaborate, and innovate new ideas gathered and developed by students. The inputs to the modified spiral model are ideas, and the outputs are creative operational projects. Considering the lack of crucial information about the effect of software spiral model in enhancing innovation, the research question that we are looking for is as follows:

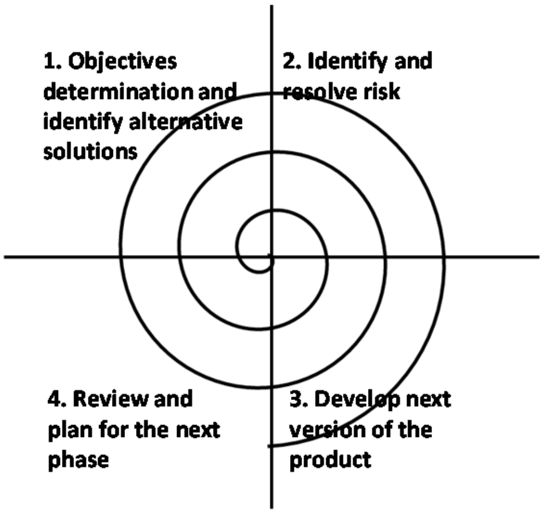

Fig. 1. Spiral Software Model, adapted from [11]

What are the effects of adopting and enhancing Boehm spiral model to inspire innovation and creativity of university students?

This research is organized as follows. Section two and Section three review the software spiral model and the motivation of the iSpiral model. Section four outlines major-related work. Section five describes the proposed iSpiral model. The research methodology is explained in Section six, while Section seven evaluates and discusses the proposed model. Section eight provides conclusions with implications and future research.

2 Software Spiral Model

The Spiral model was proposed as a way of software development that is considered iterative and risk-driven model [11]. Figure 1 shows the Spiral software life cycle model that consists of four spiral phases that prescribe the development of software.

- Determine the software product objectives, alternatives, and underlying constraints. In this phase, the phased-requirements are gathered. The objectives include software functionality, performance, and critical success factors. Consequently, alternatives are identified. The alternatives include but not limited to: build-buy or contracting under project constraints of (cost, schedule, scope).
- Evaluate the previous alternatives and identify and manage risks. Based on available alternatives from the previous phase, risks are identified, and a prototype is produced. Risks include a lack of resources experience, new technology, and imperfect process. Eventually, the risk is controlled and resolved, and project costs are controlled.

- Development and test. The current iteration of porotype is produced and tested. Typical activities include, design, coding, inspect the code, and test the product
- Plan for the next iteration. The output of the project/release is evaluated, and the next iteration is triggered. Several plans are developed, which includes: project plan, configuration management plan, test plans, and test plan.

The advantages of the spiral process are risk reduction, functionalities can be added, and software is produced for early customer feedback[12]. However, it needs specific expertise, highly dependent on risk analysis.

3 The Motivation for the iSpiral Initiative

iSpiral stands for "Innovative spiral model." The initiative was found to a private university last year. First, students got the opportunity to increase their communication when they gathered to take a commemorative photo. Then, students were allowed to communicate together through aboard with a small piece of paper that mentions what a student is willing to do. It was found that many ideas are repeated in many forms, or it could be tweaked for better results by collaborating with other students. Some students like programming while others like the design, drawing, and decorating.

A Facebook group was founded along with the proper resources of administrators from students who showed a willingness to volunteer and willing to execute a change. The group administrators observed student's posts and found that students were looking for a unique name identifying them. Therefore, the administrators of the group conducted a contest of the best logo and banner for the group. Then the number of students increased dramatically, and their collaboration increased as the group started collecting ideas using google forms.

Although students were able to collaborate and share ideas and innovations, ideas were inconsistent and irregular. Mentoring students through Facebook group or the system was not practical due to the agility of ideas and the time and cost constraints, which motivates the establishment of the iSpiral model.

4 Related Work

The literature review was carried out using the guidelines of Vom Brooke et al. [13]. This research does not summarize all of the most related works in creativity and innovation; however, it provides a balance between being all-inclusive while maintaining emphasis. The primary focus of this research is to follow creativity as a process to provide a successful outcome. Therefore, we search for significant research databases using a combination of the keywords: creativity, innovation, student engagements, cognition, and spiral. Since the ultimate goal was not to prepare a complete literature review, the discussed related work was selected manually based on the topic of interest.

4.1 Creativity concepts

Much of the creativity theories have focused on four processes known as the 4Ps, which are the person who carries out the creative process; the process that underlines creativity activities; the press in which the creativity is situated; and the product that is the ultimate output of the creativity process [14]. There is a direct relation between the process and the person. A process is an intellectual approach for techniques of creative thinking, while a creative person carries out the process considering mental habits such as expertise, autonomy, and openness. On the other hand, the press increases the degree of autonomy and resource availability to flourish creativity for the ultimate creative product.

Creativity as a problem-solving technique requires new techniques to speed up a possible solution. Incubation, where the problem-solving is stopped or rest for some time, may aid creativity by finding alternative unconscious directions of the mind [15]. As a result, incubation can be treated as a mechanism of critical thinking that can result in knowledge [16]. It guides innovative critical thinking in that it empowers "overlooking" of deluding pieces of information [17]. Therefore, without incubation, the innovator may have carried out unnecessary methodologies to solve a problem [18]. That is, solutions come mysteriously from the unconscious mind [18]. Consequently, the incubation optimizes the promoting effects of rewards on creativity[19]. It was argued that the corporations between cognitive resources could assemble responsibilities in a way to facilitate creativity that has a direct effect on mechanisms of problem-solving[20].

Problem-solving is split to multi-tasks that could be solved in two major approaches; the convergent and divergent thinking approaches. While convergent thinking targets the creation of the solely correct solution, divergent thinking (creativity) targets generating multiple answers [21]. Participants who are high in need for closure (desire for a firm answer to a question) are unskillful and less emotional to solve divergent thinking tasks [22]. Much of divergent models focus on processes that can identify and evaluate individuals[23]. Creativity is not only a problem-solving technique but the skills of combining cognitive operations. Creativity is considered an indirect result for conceptual blending, where cognitive operations blend words and images, and ideas to generate new ideas[24]. Creativity is a result of worldview organization and mending nature [26].

4.2 Creativity systems

Several systems try to identify factors that increase or explain innovations in a particular context environment. Under limited competition in trading markets, increasing rivalry increases the rate of innovation [29]. Four C's model argued that creativity is based on competence component and the historical transformation to analyze the creative process[30].

Creativity as a process has two phases: a generative and exploratory phase according to the "Geneplore" model [25]. In the first phase, an individual constructs mental representations while those structures create ideas in the second phase [25].

The Generativity Theory has a state that helps to make association and overlap between related knowledge[27]. Similarly, the Explicit-Implicit Interaction (EII) theory of creativity provides a unified explanation of relevant approaches for understanding creativity[28]. It depends on five values: explicit and implicit knowledge, implicit and explicit processes, integration of the results, and iterative processing. The Generativity Theory predicts that the creative behavior of individuals is the result of the precise blending of previous novel ideas. The theory has four competencies of creative expressions [31]:

- **Broadening**: Where one acquires experience and skills abundantly outside his expertise area of interest
- **Capturing**: New ideas are continually saved and updated for future use
- **Surroundings**: Social and physical environment stimulate novelty
- **Challenges**: Challenge seekers and management failures

The most valuable managerial competence is the providence of adequate and appropriate resources[32]. The Consensual Assessment Technique (CAT) is a way of judging the creativity of a group of artifacts that are based on the combined assessments of experts in the domain. The combined judgments can then also be used to make inferences about thought processes, environments, and personality traits that lead to creativity[33].

Learning objectives and innovation could be achieved and analyzed in a teaching system through models that are used in other domains (e.g., dynamic programming method from computer science) [34]. A great deal of innovation and creativity models has been discussed in the literature [29], [35]–[38]; however, they are domain-specific. On the other hand, unsystematic innovations approaches are subject to unapproved guidelines or advice from experts[32]. However, much of the reviewed work in the literature measures the creativity from diverse domains and different perspectives.

In a university environment, the authors were looking for a simple, easy to learn and easy to implement a solution for students. This work is deemed not to replace innovation models or strategies but to simplify a process to students.

5 Proposed iSpiral Model

Students tend to change their mind frequently; therefore, they may end up with a dead-end because they have lack of experience. Moreover, their creativity styles associate scholarly creativeness with personality types[39]. Therefore, without mentoring their thinking towards achieving goal, it is not guaranteed to get an acceptable outcome. As a result, without a creativity production process, mentoring students become subjective, especially when there are hundreds of students trying to find a solution to the same or related issue. The research problem is not related to coordinating tasks and managing time, but also integrating change and evaluating an ongoing idea over time. Accordingly, managing collaboration drives creativity, as innovation always emerges from a series of sparks [40].

Fig. 2. iSpiral Model

The problem is applied to students in general and to engineering sciecne in particular. For students in engineering science courses, a future engineer's ability to accomplish social communicative processes in modern structures of production and service has become a focal point of engineering-pedagogical considerations. Moreover, the students' ability to be part of their society by providing innovative services and creative ideas is the focal point for pedagogical engineering. Students must also be equipped with extra-ordinary tools to the demand-oriented and employment-based engineering education [41, p. 3]. Moreover, the engineering teaching staff could utilize advanced curricular structures for better course outcomes . While the teaching staff of engineering could use advanced curricular structures, students, in particular, is addressed in two main phases of self-directed learning and individual coaching that are supported by Internet-based learning scenarios[42, p. 65].

Therefore, the reported problems could resolved by a spiral model. Figure 2 shows the proposed iSpiral model. The figure shows how the objectives get converted to novel solution affected by creative ideas. As ideas evolve, it gets brighter, which means the domain of the problem gets explored, and a solution is yet to come. Readers could take attention that the proposed model is tuning the Boehm model to be used in the education context rather than replacing the original model.

The proposed spiral model is useful and valid for the education domain, as it has common factors. The pedagogy creation and design are held under constraints of the educators' capabilities, the students learning curves and styles, and the degree of elaboration that could be used towards achieving a course objective. It is not only, tools, techniques, environment, and processes used to create a pedagogy but also mentoring courses or complex topics that must be achieved in groups and under mentoring, where risks of scope creep, and cost are significant issues for initiatives success.

Although many students did not know much about the iSpiral model, top talented and trained students understood it primarily after it got explained in a top-down contextual approach. After attending one seminar from an innovation entrepreneurship company, many ideas flood into the iSpiral system. The iSpiral model has four phases:

5.1 Identify objectives

In this stage, the project owner (the founder of iSpiral) determines and list out the updated backlog of objectives that need to be achieved based on university guidelines and constraints. Then, he prioritizes the objectives and makes sure that they are Specific, Measurable, Achievable, Realistic, and Time-bound (SMART). The prioritization process is much like requirements prioritization process. However, the main constraints are the time and the budget. The objectives guide student ideas directly by collaboration and mentoring and indirectly by transitive relation between objectives and available constraints of the environment. Moreover, evolving ideas (changes) can be triggered based on student interactions, compunction, and collaboration. Consequently, an initiative idea progress is tracked and managed by using a customized application for this task.

5.2 Identify risks

The iSpiral team meets regularly, and as a result, the risk register of related initiatives gets updated. New identified risks are registered while current status or risk levels may get changed. The risk register carries out information of responsible students and mitigation plans. Since the students have little experience with risk management, the risk was managed leaned with PMI risk management.

5.3 Develop and test

Development is the core process of the iSpiral model, and it needs continuous follow up because it is subject to continuous change resulted from collaboration and testing outcome ideas online with risk mitigations. Instead of a computer program that ends with code, the model ends up with an approved prototype of an idea. A detailed design of the proposed idea is explained and reviewed with collaborative innovators along with the project owner. Then the idea prototype gets constructed (referred to as code in the software development era). Then, the idea gets tested by the project owner and verified with questionnaires or discussion online with other students. Finally, this process ends up with a product that could be used or a mature idea that could evolve again.

5.4 Plan for the next iteration

At this stage and based on an evaluation of the previous phase, a new plan gets imitated for the next iteration. Some ideas get implemented inside the campaign while others could influence society.

6 Research Methodology

The research methodology was followed using the guidelines of Descombe[43]. One objective of this research is to enhance students engagement in innovation activities; therefore, a survey has been selected as a research strategy to measure aspects of trends of students' engagement. The author runs a pre-survey of student behavior skills using “The innovator's DNA” [34]. Since it was complex to deduce an ideal strategy, the Grounded theory approach was not considered an applicable approach in our context.

This research uses a group-administered survey (a questionnaire) using a Likert scale. The questionnaire produces a series of data in a short time at a relatively low cost. Students were asked to do a self-assessment survey (1=strongly disagree; 2=disagree; 3=neither agree nor disagree;4=agree;5=strongly agree). The objective was to know the percentage of students in each category of the innovator's categories; therefore, the students' feelings and emotions that could be obtained by interviews approach were not taken into consideration.

A total of 300 students were selected at random from different colleagues in the anonymous university. Data were analyzed using mixed techniques of pre-surveys, theoretical comparison approaches, and a post case study. For the ethical consideration, the survey and the case study where conducted following the fundamental ethical principles. Participants in this research were briefed on the purpose of the research study, and they were informed that their responses are entirely voluntary. All data of the participants were private and confidential.

7 Evaluation and Discussion

7.1 Student engagement and behavioral discovery skills

Students who involve more frequently in educationally focused activities outside the classroom are more satisfied and are more likely to persist and graduate. Creativity at the individual level does not guarantee innovation within student groups. The greater of the student knowledge base and level of curiosity, the more ideas, patterns, and combinations students can achieve, the more likely innovative products and services.

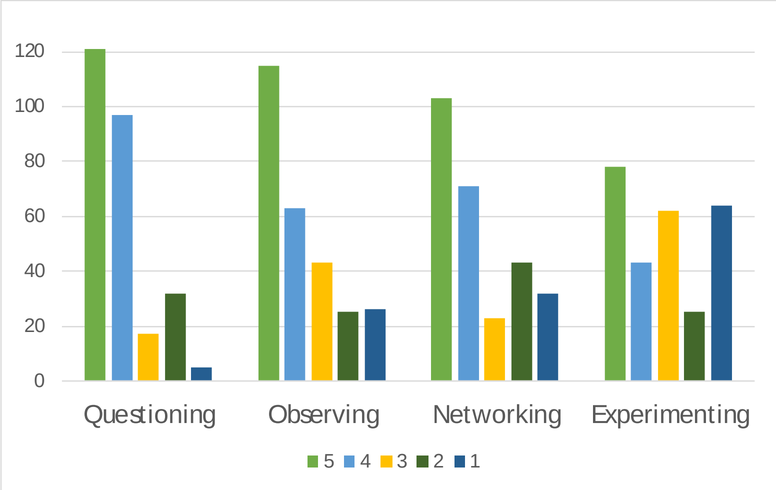

Fig. 3. Participants response using Likert scale

Many surveys were used to analyze students' engagement or innovation; however, there was no consensus on the conceptual foundation [45]. These surveys include the National Survey of Student Engagement (NSSE) in the USA, the UK Experience Survey (UKES), and the Australian Student Experience Survey (SES). All of the emphasis on a superior or slighter extent on the behavioral aspects of student engagement. This research carried out a simple survey to detect student behavior engagement towards innovation based on [44]. Students were asked to do a self-assessment survey using a Likert scale (5=strongly agree, and 1=strongly disagree). Table 1 shows the four discovery skills and the related survey question presented to students.

Table 1. Pre-survey of student behavior skills using "The innovator's DNA" [44].

Discovery Skill	Survey Question
Questioning	I always asked my teacher and peers why and what-if questions
Observing	I like to travel and follow new trends in my favourite area or observe changes in my faculty.
Networking	Dynamically hunt ideas by discussing with people even if they have a completely different opinion
Experimenting	I always try out new experiences and pilot new ideas

Three hundred students answered the pre-survey. After filtering, 272 students' answers were used in subsequent steps (shown in Figure 3). Figure 3 shows that students tend to ask innovative questions; however, many of them do not continue to the last crucial step (Experimenting). Moreover, students who like to do observation seems to do observation not for innovation purpose but just for knowledge and personal satisfaction. Table 2 shows the total number of respondents per Likert scale and the student behavior for each discovery skill. Although students practice "Questioning" and

"Observing" skills, most of them are neutral to "Networking" and "Experimenting" skills.

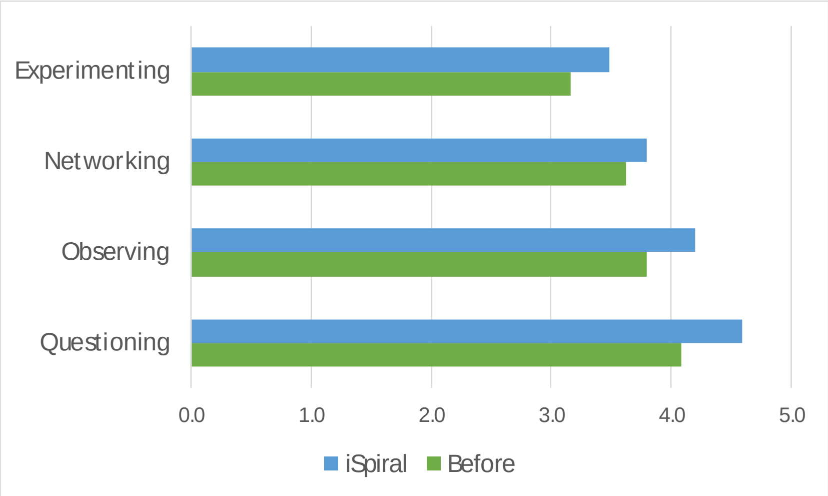

Fig. 4. Participants responses after implementing iSpiral

The same survey was run one year after implementing iSpiral model. The authors tried to select almost the same students who answered the first questionnaire. Almost 94% of the old students answered the new questionnaire. Figure 4 shows the survey results. The results showed that there is an improvement in all four categories of Innovator's DNA by 2-5 %, which implies that the iSpiral model was efficient and effective. According to the figure, the students tend to be more innovative, most likely due to the application of the iSpiral model. The reasons behind the enhancements are due to the application of iSpiral that increased student engagement and collaboration. Moreover, iSpiral places creativity as a significant milestone in daily student life.

Although the provided approach did not measure the knowledge that was gained by students after one year, the research showed that new students were willing to join regardless of their year of study.

Table 2. Pre-survey of student behavior skills using "The Innovator's DNA" [44].

	Likert Scale					
Discovery Skill	***5***	***4***	***3***	***2***	***1***	**Student Behavior**
Questioning	121	97	17	32	5	4.1
Observing	115	63	43	25	26	3.8
Networking	103	71	23	43	32	3.6
Experimenting	78	43	62	25	64	3.2

7.2 Evaluating the proposed iSpiral model

To our knowledge, no complete creativity model exists in general. The proposed model is an overarching approach intended to implement and guide an innovative idea from initiation to evolution.

Measuring creativity is not a direct process, and many times is subjective. This research neglect the aspects of psychology in innovation and focus on the 4Ps of creativity. Many approaches try to measure person creativity using IQ tests, leaving a qualitative approach for ideas. The framework of [46] consists of novelty, and impact aspects and argues that it can measure creativity. This work compares selective innovative models topographies with deduced criteria from the literature. The suggested criteria are as follows:

Flexibility: The capacity to be elastic and deal with unpredictable changes, risks, and issues in resources, business process, target product, collaborators, and the environment [14].

Collaboration: The ability to generate new ideas based on current running ones, which are a combination of divergent and convergent ideas. It is found that correlating social community structure with character and overall organizational performance will increase innovation[47].

Control and governance: The ability to mentor ideas and divert thinking toward a specific domain (e.g., society). Good governance powers innovation[48].

Innovators' style: The capacity of dealing with the innovator characteristic, including their learning styles, and personal skills. This component will help the mentor directs students to their objectives based on their preferences.

Scope: Measuring the value of the innovated product, process, or traits of the innovator.

Table 3. iSpiral compared with related innovation techniques.

Criterion	iSpiral Model	[23][46]	[31] [32]	[30]	[26][3]
A	☑	☒	☑	☒	☑
B	☑	☒	☒	☒	☒
C	☑	☒	☑	☑	☑
D	☑	☑	☑	☑	☑
E	Process	Person	Management Guidelines	Descriptive	Product

Table 3 shows the comparison of iSpiral and creativity models extracted from the literature as a proof of concept. A fully available criterion (☑) refers to the match of the criterion to the compared model, while (☒) indicates that the criterion is not applicable. From the table, it could be deduced that all models take into consideration the cognitive and personal skills of innovators. Moreover, all models agree on the need for control and governance to solve or provide services to open problems in real environments. One useful model that explains creativity is the model of [28]; however, it is a non-operational theoretical model. This research deduces that all the studied creativity approaches suffer from a limited guided process for synthesis and risk management, as shown the first (A) and last (D) criteria.

7.3 A case study of the iSpiral model

The proposed approach was applied to the university last year. After training students on the new proposed model, team leaders start their initiatives under the authors' mentoring. We discovered that students like to communicate with peers to come up to a solution rather than the teachers. This study where held under a disclosure agreement, where some innovations are not yet mature enough; therefore, this research will not report further details of student's innovations. However, they will be followed and executed in further upcoming research.

We evaluated the proposed iSpiral model based on a set of criteria collected before and after the application of the model, as shown in Table 4. Results showed that the 4Ps of creativity was enhanced. The competencies were enhanced for students; the press (environment) were prepared to accept and execute innovations. Moreover, the new proposed iSpiral innovative process was established and followed. Although the final products were not fully reported as part of this paper for space limitations, the number and quality of ideas have been increased dramatically. Therefore, the implication of the proposed model will affect pedagogy design and could be used as a problem-solving technique for engineering pedagogy.

This research also carries out an additional step to verify the concept of the proposed innovative mode. The model was also evaluated by two senior entrepreneurs. They were introduced to the model components, and they were shown how students had applied the model in practice. They also were introduced to a part of student innovations in a ceremony where students' ideas were evaluated. The entrepreneurs were happy to have such a novel idea, and one local company requested to support some running projects.

Table 4. Situation before and after applying the spiral model.

Criteria	**Before the Application of the Spiral Model**	**iSpiral Model**
Number of volunteers	A few and irregular	A large group of more than 200 volunteers. (more than 200% increase). The percentage of volunteers increase draws attention that the iSpiral was gaining more attraction from students due to the increase of Networking dimension of the innovator NDA.
Number of activities	Few, almost 10/semester	More than 40 /semester (30% increase)
Collaboration	Few uncontrolled groups of students	More than 20 groups specialized in different areas of innovation and study (15% increase)
Type of activities	Mostly academic	Academic and non-academic, and community-serving. For example, one medical innovation won many prizes worldwide. (20% increase)
Competencies	Was not evaluated	As many ideas were updating the previous ones, the student competencies were enhanced. It was found that students can quickly transfer knowledge and creativity by directly by a student to student communication

However, the proposed model may not be enough to be generalized in other domains as applied in the academic domain. Therefore, exceptional knowledge of student behavior may be extracted from student learning profiles using machine learning techniques, similar as they are re applied in the software engineering domain [49], [50]. Similarly, semantic similarity could be used to connect students who have similar interest or behavior based on social media content [51], [52]. Moreover, the mentor, policies, regulations, budget, and adequate and appropriate resource remains an open issue for a large-scale solution.

8 Conclusion

This paper has proposed an updated model of the spiral software development model to inspire students' innovations. The proposed iSpiral (innovative Spiral) model was able to reveal and manage risks of student's innovations, given a low budget and rigid constraints. The proposed model is a simple, easy to use and provides a guideline for the implementation of a creative process for students. This research inferred a set of innovation process evaluation criteria and used it to measure the proposed model. The proposed iSpiral were compared with the selected set of innovative models, where it was shown that it is suitable where risk management and mentoring are required in tandem. Consequently, the students cultivate innovative operational ideas. In the future, the authors plan to extend the model to other universities and explore details of students' projects.

9 References

[1] G. David, "Knowledge, Creativity and Innovation," *J. Knowl. Manag.*, vol. 2, no. 1, pp. 5–13, Jan. 1998.

[2] K. Panagiotis and E. Berki, "Nurturing creative thinking," *Int. Acad. Educ.*, vol. 25, no. Int. Acad. Educ., 2014.

[3] D. Henriksen *et al.*, "Creativity and Technology in Education: An International Perspective," *Technol. Knowl. Learn.*, vol. 23, no. 3, pp. 409–424, 2018.

[4] B. Laduca, A. Ausdenmoore, J. Katz-Buonincontro, K. Hallinan, and K. Marshall, "An arts-based instructional model for student creativity in engineering design," *Int. J. Eng. Pedagog.*, vol. 7, no. 1, pp. 34–57, 2017. https://doi.org/10.3991/ijep.v7i1.6335

[5] W. G. Hernández, "Detection of potentially creative students for informatics activity.," *Int. J. Eng. Pedagog.*, vol. 6, no. 1, pp. 80–84, 2016.

[6] J. S. Bruner, *The process of education:[a searching discussion of school education opening new paths to learning and teaching]*. Vintage Books, 1960.

[7] B. C. Gibbs, "Reconfiguring Bruner: Compressing the spiral curriculum," *Phi Delta Kappan*, vol. 95, no. 7, pp. 41–44, 2014. https://doi.org/10.1177/003172171409500710

[8] S. E. Carlson, D. G. Rees Lewis, E. M. Gerber, and M. W. Easterday, "Challenges of peer instruction in an undergraduate student-led learning community: bi-directional diffusion as a crucial instructional process," *Instr. Sci.*, vol. 46, no. 3, pp. 405–433, Jun. 2018. https://doi.org/10.1007/s11251-017-9442-0

[9] B. S. Selznick and M. J. Mayhew, "Measuring Undergraduates' Innovation Capacities," *Res. High. Educ.*, vol. 59, no. 6, pp. 744–764, Sep. 2018. https://doi.org/10.1007/s11162-017-9486-7

[10] T. L. Larkin, "The Creative Project: Design, Implementation, and Assessment," *Int. J. Eng. Pedagog.*, vol. 6, no. 1, pp. 72–79, 2016.
[11] B. W. Boehm, "A spiral model of software development and enhancement," *Computer (Long. Beach. Calif).*, vol. 21, no. 5, pp. 61–72, 1988.
[12] M. R. Ayyagari and I. Atoum, "CMMI-DEV Implementation Simplified:A Spiral Software Model," *Int. J. Adv. Comput. Sci. Appl.*, vol. 10, no. 4, pp. 445–450, 2019.
[13] J. Vom Brocke, A. Simons, B. Niehaves, K. Riemer, R. Plattfaut, and A. Cleven, "Reconstructing the giant: On the importance of rigour in documenting the literature search," in *Proc 17th European conference on information systems, Verona, paper*, 2009, vol. 161.
[14] D. Spendlove, "The locating of emotion within a creative, learning and product orientated design and technology experience: person, process, product," *Int. J. Technol. Des. Educ.*, vol. 18, no. 1, pp. 45–57, 2008. https://doi.org/10.1007/s10798-006-9012-2
[15] M. Csikszentmihalyi, *Flow and the psychology of discovery and invention*, vol. 56. New York: Harper Collins, 1996.
[16] K. J. Gilhooly, G. Georgiou, and U. Devery, "Incubation and creativity: do something different," *Think. Reason.*, vol. 19, no. 2, pp. 137–149, 2013. https://doi.org/10.1080/13546783.2012.749812
[17] T. Ward, "Cognition, creativity, and entrepreneurship," *J. Bus. Ventur.*, vol. 19, no. 2, pp. 173–188, 2004.
[18] S. M. Smith, "Fixation, incubation, and insight in memory and creative thinking," *Creat. Cogn. approach*, vol. 135, p. 156, 1995.
[19] Z. Zhang, W. Zhang, X. Wu, T. Tan, and J. Luo, "Incubation optimizes the promoting effects of rewards on creativity," *PsyCh J.*, 2018. https://doi.org/10.1002/pchj.251
[20] F. Mochi and N. Madjar, "Interruptions and Multitasking: Advantages and Disadvantages for Creativity at Work," in *Individual Creativity in the Workplace*, Elsevier, 2018, pp. 103–127. https://doi.org/10.1016/b978-0-12-813238-8.00005-x
[21] J. P. Guilford, "The nature of human intelligence.," 1967.
[22] M. K. Wronska, A. Bujacz, M. A. Gocłowska, E. F. Rietzschel, and B. A. Nijstad, "Person-task fit: Emotional consequences of performing divergent versus convergent thinking tasks depend on need for cognitive closure," *Pers. Individ. Dif.*, 2018. https://doi.org/10.1016/j.paid.2018.09.018
[23] K. Japardi, S. Bookheimer, K. Knudsen, D. G. Ghahremani, and R. M. Bilder, "Functional magnetic resonance imaging of divergent and convergent thinking in Big-C creativity," *Neuropsychologia*, vol. 118, pp. 59–67, 2018. https://doi.org/10.1016/j.neuropsychologia.2018.02.017
[24] G. Fauconnier and M. Turner, *The way we think: Conceptual blending and the mind's hidden complexities*. Basic Books, 2008.
[25] T. B. Ward, "What's old about new ideas," *Creat. Cogn. approach*, pp. 157–178, 1995.
[26] R. E. Beaty, A. P. Christensen, M. Benedek, P. J. Silvia, and D. L. Schacter, "Creative constraints: Brain activity and network dynamics underlying semantic interference during idea production," *Neuroimage*, vol. 148, pp. 189–196, 2017. https://doi.org/10.1016/j.neuroimage.2017.01.012
[27] G. Liane and S. Adam, "Creative Interference and States of Potentiality in Analogy Problem Solving," 2011.
[28] S. Hélie and R. Sun, "Incubation, insight, and creative problem solving: a unified theory and a connectionist model.," *Psychol. Rev.*, vol. 117, no. 3, p. 994, 2010. https://doi.org/10.1037/a0019532

[29] R. Gilbert, C. Riis, and E. Riis, "Stepwise Innovation by an Oligopoly," *Ssrn*, 2017. https://doi.org/10.2139/ssrn.2964062
[30] J. C. Kaufman and R. A. Beghetto, "Beyond big and little: The four c model of creativity," *Rev. Gen. Psychol.*, vol. 13, no. 1, pp. 1–12, 2009.
[31] R. Epstein, "Generativity theory and creativity.," 1990.
[32] R. Epstein, K. Kaminaka, V. Phan, and R. Uda, "How is creativity best managed? Some empirical and theoretical guidelines," *Creat. Innov. Manag.*, vol. 22, no. 4, pp. 359–374, 2013. https://doi.org/10.1111/caim.12042
[33] J. Baer and J. C. Kaufman, "Assessing Creativity with the Consensual Assessment Technique," in *The Palgrave Handbook of Social Creativity Research*, I. Lebuda and V. P. Gl\uaveanu, Eds. Cham: Springer International Publishing, 2019, pp. 27–37. https://doi.org/10.1007/978-3-319-95498-1_3
[34] X. Liu, L. He, L. Xin, and H. Le, "Innovation and Entrepreneurship Talents Cultivating: Systematic Implementation Path of 'Knowledge Interface and Ability Matching,'" *Int. J. Emerg. Technol. Learn.*, vol. 13, no. 08, pp. 117–132, 2018. https://doi.org/10.3991/ijet.v13i08.9041
[35] Cambridge Assesment International Education, "Developing the Cambridge learner attributes," vol. 11, no. page 54, pp. 53–74, 2011.
[36] J. T. Eckhardt, M. P. Ciuchta, and M. Carpenter, "Open innovation, information, and entrepreneurship within platform ecosystems," *Strateg. Entrep. J.*, vol. 12, no. 3, pp. 369–391, 2018. https://doi.org/10.1002/sej.1298
[37] K. A. Skarupski, A. Gross, J. A. Schrack, J. A. Deal, and G. B. Eber, "The Health of America's Aging Prison Population," *Epidemiol. Rev.*, vol. 40, no. 1, pp. 157–165, 2018. https://doi.org/10.1093/epirev/mxx020
[38] T. T. Sousa-Zomer and P. A. Cauchick Miguel, "Sustainable business models as an innovation strategy in the water sector: An empirical investigation of a sustainable product-service system," *J. Clean. Prod.*, vol. 171, pp. S119–S129, 2018. https://doi.org/10.1016/j.jclepro.2016.07.063
[39] M. Z. Wang, W. Chen, C. Zhang, and X. L. Deng, "Personality types and scholarly creativity in undergraduate students: The mediating roles of creative styles," *Pers. Individ. Dif.*, vol. 105, pp. 170–174, 2017. https://doi.org/10.1016/j.paid.2016.09.050
[40] K. Sawyer, *Group genius: The creative power of collaboration*. Basic Books, 2017.
[41] S. Kersten, H. Simmert, and D. Gormaz, "Engineering Pedagogy at Universities in Chile—A Research and Further Education Project of TU Dresden and Universidad Autónoma de Chile," in *Expanding Learning Scenarios. EDEN Conference Barcelona*, 2015.
[42] H. Hortsch, *Umsetzung von unternehmensindividueller Weiterbildung in Kleinunternehmen aus dem Bereich Natur+ Umwelt: zielorientiertes Coaching initiiert selbstgesteuertes Lernen (ZICONU). Didaktisch-methodische Ansätze und Lösungen für KMU: Abschlussbericht des Model*. Techn. Univ., Fak. Erziehungswiss., Inst. für Berufspädagogik, 2006.
[43] M. Denscombe, *The good research guide: for small-scale social research projects*. McGraw-Hill Education (UK), 2014.
[44] J. Dyer, H. Gregersen, and C. M. Christensen, *The innovator's DNA: Mastering the five skills of disruptive innovators*. Harvard Business Press, 2011. https://doi.org/10.1111/j.1540-5885.2012.00933_2.x
[45] G. F. Burch, N. A. Heller, J. J. Burch, R. Freed, and S. A. Steed, "Student engagement: Developing a conceptual framework and survey instrument," *J. Educ. Bus.*, vol. 90, no. 4, pp. 224–229, 2015. https://doi.org/10.1080/08832323.2015.1019821

[46] D. Piffer, "Can creativity be measured? An attempt to clarify the notion of creativity and general directions for future research," *Think. Ski. Creat.*, vol. 7, no. 3, pp. 258–264, 2012. https://doi.org/10.1016/j.tsc.2012.04.009
[47] P. A. Gloor, M. Paasivaara, D. Schoder, and P. Willems, "Finding collaborative innovation networks through correlating performance with social network structure," *Int. J. Prod. Res.*, vol. 46, no. 5, pp. 1357–1371, 2008. https://doi.org/10.1080/00207540701224582
[48] A. Mungiu-Pippidi, "Corruption: Good governance powers innovation," *Nat. News*, vol. 518, no. 7539, p. 295, 2015. https://doi.org/10.1038/518295a
[49] I. Atoum, "A Novel Framework for Measuring Software Quality-in-use based on Semantic Similarity and Sentiment Analysis of Software Reviews," *J. King Saud Univ. - Comput. Inf. Sci.*, p. , 2018. https://doi.org/10.1016/j.jksuci.2018.04.012
[50] M. R. Ayyagari and I. Atoum, "Understanding Customer Voice of Project Portfolio Management Software," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 5, pp. 51–56, 2019.
[51] I. Atoum, "Scaled Pearson's Correlation Coefficient for Evaluating Text Similarity Measures," Mod. Appl. Sci., vol. 13, no. 10, pp. 26–38, 2019
[52] . I. Atoum and A. Otoom, "Efficient Hybrid Semantic Text Similarity using Wordnet and a Corpus," International Journal of Advanced Computer Science and Applications (IJACSA), vol. 7, no. 9. The Science and Information (SAI) Organization Limited, pp. 124–130, 2016.

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