Projective Identity and Procedural Rhetoric in Educational Multimedia: Towards the Enrichment of Programming Self-Concept and Growth Mindset with Fantasy Role-Play

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ABSTRACT
There is a growing movement in the behavioral sciences towards exploring more situated, pragmatic and ontological accounts of human learning. Positive psychology shows that a reciprocal relationship may exist between self-concept and the development of expertise, while social psychology reveals that mindsets about the nature of personal traits can have profound impacts on practice behavior. Thus, nurturing psychological constructs through the learning environment may empower students, enabling them to learn more effectively. Educational multimedia is known to support learning in a range of contexts, but its role in facilitating such self-enrichment has seldom been explored. Consequently, it is not clear which designs can aid both self enhancement and skill development. This doctoral symposium paper proposes that an interplay between projective identity and procedural rhetoric, delivered in the form of a fantasy role-playing experience, could be one such practice. Early experiments in the area of introductory programming show promise, but raise questions about external validity, educationally relevant effect sizes and how multimedia elements within the tool could be utilized more effectively to enhance these effects.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems; K.3.1 [**Computers and Education**]: Computer Uses in Education.

Keywords
Self-Concept, Projective Identity, Procedural Rhetoric, Implicit Beliefs, Self-Enhancement, Mindset, Programming, Multimedia, Fantasy, Role-Play, Education, Learning.

1. INTRODUCTION
Educational multimedia is widely used to support learning. Applications include: instructional videos; visualizations; training simulations; and serious games. Part of its popularity can be attributed to its availability, as learners in many parts of the world are able to access multimedia-enabled instruction due to the growing ubiquity of computer-based tools [24]. Furthermore, multimedia communication is often informed by the principles of cognitive science, so the delivery of learning material in such cases is optimized for human information processing [21, 23].

However, while retention and transfer of knowledge are highly desirable, direct instruction is not the only goal of education. At the tertiary level, in particular, there is a movement towards learner-centered paradigms which champion autonomy [2] and encourage self-regulation [41]. This has implications for practical disciplines, such as programming, where it is desirable for learners to immerse themselves in a regime of ongoing and reflexive deliberate practice. This is because ten years of such practice is often needed to obtain substantial expertise [10, 38].

Yet, despite this renewed emphasis, educators do not appear to have overcome some of the most pervasive challenges in introductory programming [13, 35]. Many novices do not appear to practice programming regularly, claiming they experience apprehension and discomfort when they attempt to do so [31]. Some authors describe this as *programming trauma* [17], and there is some neurological evidence which suggests such anxiety has a relationship with regions of the brain associated with visceral threat detection and pain [20]. Thus, negative experiences and their impact on avoidance behavior is an area of concern.

Scott and Ghinea [32] have reflected on several potential barriers that may influence programming avoidance. These being: the "radical novelty" of the learning material [8]; beliefs about the nature of programming aptitude [9, 39]; in addition to the relationship between self-concept and achievement [16, 22, 37]. They propose analytical and adaptable approaches to the design of learning environments, applying soft scaffolding, ongoing informative feedback, and a focus on self-enhancement alongside skill development, could help to overcome these barriers.

However, there are challenges in adopting these proposals. They do not trivially scale to large cohorts of students. Moreover, their realization is often left to teaching assistants who may not receive significant training on how to provide appropriate feedback, or in educational psychology more generally [3]. This is a significant disadvantage because appropriate feedback is pertinent to nurturing self-concept [27] and appropriate beliefs [6, 26].

The means through which these principles can be realized, nevertheless, do not rely solely on faculty alone. Educational multimedia and adaptive hypermedia systems can be used to support scalability. Therefore, suitable measurement, scaffolding and feedback for individual learners can be managed through virtual learning environments. This enables pedagogies that account for barriers to deliberate practice. So, what roles can educational multimedia have in facilitating self-enrichment?

MM'13, October 21–25, 2013, Barcelona, Spain.
ACM 978-1-4503-2404-5/13/10.
http://dx.doi.org/10.1145/2502081.2502209

2. BACKGROUND

One role that multimedia e-learning could support is the development of a strong learning identity. Pertinent to this, is the self-concept construct [16]. Recent work in this area suggests that a reciprocal relationship exists between self-concept and achievement, where it is defined as: individual self-perceptions about ability, situated within a sphere of activity, formed through experience with and interpretations of one's environment [16, 22]. Thus, a positive self-concept can facilitate achievement [37].

A practice that could reinforce self-concept is the use of a fantasy role-play within a dramatic narrative [34]. There has been some qualitative success in *Space Mission: Ice Moon*, enabling students to "think and act like scientists" [7] and among the creative learning environments, a similar approach can be seen in *GameStar Mechanic* [30]. Thus, it could be used to prepare less confident students for project-based learning, as in [29]—but conveying preparatory material in a way that avoids the pitfalls of just-in-time instruction, where the pace can create pressure.

Based on Gee's [12] notion of "projective identity", the role-play operates as an exploration of a virtual identity through embodied activity. It is argued that, as learners develop their identity while immersed in a role, it reinforces the real-world identity relating to that role. Thus, acting as a Lacanian mirror stage [18], learners project their beliefs onto their character and then witness a transformation as a consequence of the narrative. Subsequently, they reflect upon and potentially adopt the change.

While there is limited evidence, Yee and Bailenson [40] describe a somewhat similar phenomenon: the Proteus Effect. Under experimental conditions, they showed that manipulating the avatars of participants in a virtual environment had an impact on their attitudes and behavior. Furthermore some of these changes were maintained when measured a short time after the experiment, outside of the virtual environment. In another study, vicarious reinforcement was applied to avatars within a virtual world, changing their appearance in accordance with participants' behavior; which, in turn, reinforced positive habits [11]. This further supports the notion that transforming virtual characters can change attitudes that transfer to real-world contexts.

Another role that multimedia e-learning could support is changing beliefs about aptitude. According to this line of research, learners can have implicit beliefs about whether their personal traits are set (the fixed mindset) or malleable (the growth mindset). As a result, when learners encounter difficulties, those with a fixed mindset often assume maladaptive learning strategies. However, those with a growth mindset tend to remain resilient, applying a mastery-orientated approach [9, 26, 39].

There are few studies on this topic within the domain of computer science education. However, those that have been conducted suggest a domain-specific impact. There appears to be a distinct mindset for programming aptitude [33], and an intervention study targeting novice software developers only showed success when growth messages were reinforced with a programming crib-sheet [6]. In line with work that suggests feedback practice affects mindsets [26], feedback contextualization may also be needed.

Multimedia learning environments, however, can be designed to communicate immediate, situated and pervasive messages that promote the growth mindset. This can be achieved using a mechanism such as procedural rhetoric [4]. Unique to interactive media, this approach does not argue directly but rather allows a position to emerge through the dynamics of a system. For example, presenting a compiler as an apologetic character in need of assistance has helped novices to see compilation errors as challenges to be overcome [19]. Thereby, subtly emphasizing how skill improves as a consequence of effort.

3. PROPOSED APPROACH

This research investigates the impact of embedding a fantasy role-play within a multimedia learning tool. The proposed design leverages projective identity and procedural rhetoric, aiming to enhance programming self-concept and promote a growth mindset towards programming aptitude. The hypothesis is that such self-enrichment will encourage students to engage in deliberate practice. Central to this thesis is the notion that learners' beliefs about themselves influence their behavior [9, 32]. Thus, due to the strong nature of the emotions that arise while learning to program [17, 31], the work has been situated within the control-value appraisal theory of achievement emotion and motivation [28]. The focus is three section of a causal chain: the relationship between self-beliefs and value-control appraisals; how these appraisals influence emotions during programming tasks; and how these influence programming practice behavior. Thus, the framework, shown below in Figure 1, is proposed:

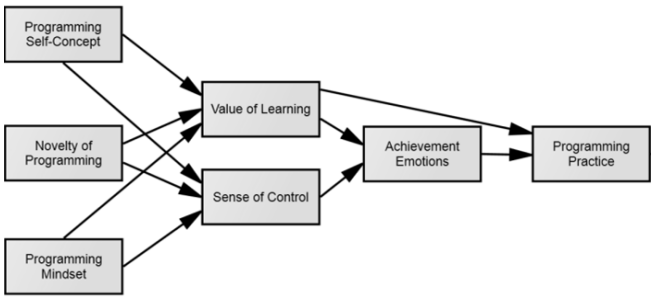

Figure 1. Proposed Conceptual Framework

Mindsets have an impact on students' sense of control over their learning, while self-concept reinforces the value of it. These beliefs, alongside students' familiarity with the learning material, form interactions affecting value-control appraisals. With such appraisals then influencing the emotions that students experience as they encounter challenge. For example, anxiety and frustration with low-control and high-value. This has an impact on practice behavior, which may be mitigated by high value. It is critical to first validate this framework to understand the potential impacts of the tool. Thus, the research is organized into two core branches.

The first branch of the project consists of three core elements: *psychometric scale construction*, to ensure that measurement is rigorous; and *correlational studies*, that analyze survey data to determine whether the hypothesized relationships exist. It is important to note that several relationships in the model may be reciprocal in nature [22]. This is based on evidence which suggests that, should educators enhance self-beliefs without also improving level of ability, then the gains in self-belief are likely to be short-lived [16]. Thus, the third core element will consist of *longitudinal studies*, using survey data to explore changes over time. This will situate the work in the wider context of learning to program, providing an indication of the educational relevance of detected effect sizes.

The second branch of the research will involve the development and evaluation of the proposed tool. This will consist of two core elements: *qualitative design research*, prototyping the design using a human-centered approach to ensure appropriateness and usability; and *experimental studies*, conducting experimental (pragmatic) trials to evaluate the effectiveness of tool.

4. WORK IN PROGRESS

Work has begun on psychometric scale development and an exploration of the correlations between the relevant psychological constructs. However, this has not been without challenge. In two initial surveys, reported in [33] and [34], response rates were low. While non-response bias was examined, concerns have been raised about representativeness. Thus, replication at other institutions, using random sampling strategies, are necessary to address these concerns about external validity. Nevertheless, the adaptation of several general self-belief constructs to the introductory programming context demonstrated adequate psychometric properties [34]. Furthermore, the notion of a programming-specific mindset construct was supported [33].

While these surveys were conducted, an initial prototype of the tool was developed, shown below in Figure 2. This implemented a simple 20 minute debugging exercise, intended to encourage students to improve their ability at identifying errors in existing Java code. A projective identity was embedded by enabling users to select an avatar and move around a virtual environment, assuming the role of a computer systems specialist on an advanced interstellar spaceship. In the role-play, the ship had become damaged, so repair robots had to be programmed to navigate the ship and repair various problems. Students were provided instruction before each task, receiving encouragement and advice by characters after submitting a solution. Upon success, they would then provided feedback based on the time taken and mistakes made.

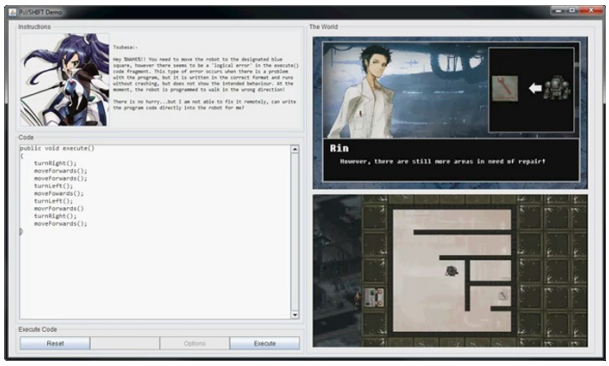

Figure 2. An Early Prototype of the Proposed Tool [34]

The prototype was intended to inform the design. However, as reported in [34], it was examined under experimental conditions to explore the feasibility of the study design. Inspired by several similar studies that focused on learning [14, 15, 25], a randomised trial using an *added value* approach [1] was adopted. A version tool including fantasy role-play (experimental) was compared to one without (control) using the pre-test post-test parallel group design. The sample consisted of 36 first and second year undergraduate students, several weeks into an introductory programming course. Typically, these students had little, or no, experience writing code prior to the start of this course.

An ANCOVA (Analysis of Covariance) revealed that the fantasy role-play version was more effective than the control case at enhancing self-concept ($F[1, 35] = 4.181$, $p < .05$, $\eta_p^2 = .112$). Nevertheless, the gain scores, illustrated below in Figure 3, reveal a modest increase in the experimental condition. This is challenging to place into context because a series of small effects may become educationally relevant over time. Thus, the power of the experiment should be increased. However, the result may also suggest further design considerations are needed. For example, what level of presence and embodiment (the sensation of being immersed in a virtual environment while inhabiting another self; see [5, 12, 25, 36]) is needed for the formation of a projective identity? Then, what multimedia features will facilitate that level? Does this lead to an acceptable trade-off with respect to extraneous content that violates the coherence principle [23]?

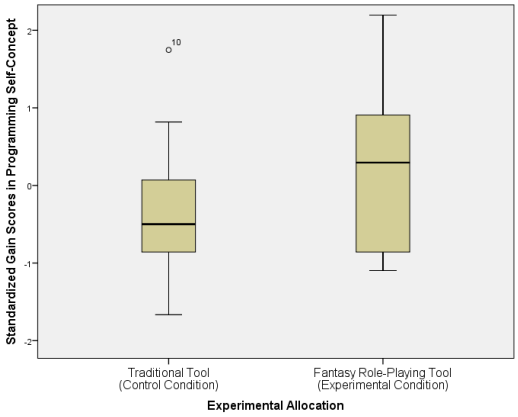

Figure 3. Distribution of Self-Concept Gain Scores [34]

5. EXPECTED CONTRIBUTION

It is anticipated that this research will be ongoing, but beyond the tool itself, three core contributions are expected:

- A validated psychometric scale that enables educators in tertiary institutions to measure programming aptitude mindset and programming self-concept;
- A model that explores the impact of programming self-concept and programming aptitude mindset on programming practice behavior;
- Experimental evidence that demonstrates the efficacy of educational multimedia, applying the notions of projective identity and procedural rhetoric, to enhance programming aptitude mindset and self-concept.

If it can shown that such self-enrichment effects exist, and they are educationally relevant, there could be significant implications for the design and use of multimedia to support affective goals in education. This will lead to further work exploring what media elements and arrangements provide effective support.

6. SUMMARY

It is hypothesized that high self-concept and a growth mindset enable desirable learning behaviors. Thus, this work explores how educational multimedia could facilitate an intervention. It is proposed that procedural rhetoric, using narrative and interactive characters to subtly persuade learners, and projective identity, shaping interactivity through the lens of a virtual character, can create self-enriching experiences that empower programming novices. Consequently, leading to higher achievement.

Initial results are promising, but have several limitations. Thus, results should be replicated to address concerns. Furthermore, the initial experiment was shown to have a small effect. It is unclear whether such a modest gain is educationally significant, as it could aggregate over time leading to long-term impact. Therefore, longitudinal study is necessary, once the research model has been evaluated. However, it also alludes that additional design considerations, such as the role of multimedia, are necessary.

7. ACKNOWLEDGMENTS

This work is being conducted under the supervision of Gheorghita Ghinea, with funding provided by Brunel University.

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