Personalized Blended Learning via New Media and Formative Assessment

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***Abstract*—In this paper we describe an ongoing multi-year project to improve the learning outcomes in relation to advanced Excel competence for first year undergraduate business students within an Information Systems (IS) course with very large enrolment. The students study within a blended learning environment that combines face-to-face and online content delivery. The first stage of the project defined the learning outcomes and pedagogical framework for teaching end-user Excel programming to the students. The theory utilized for this stage was the Four Resources Literacy Education model. The second stage involved the development and delivery of additional scaffolding of pedagogical content via audio/visual (MP4) streaming/download. The most recent stage comprises a trial in which formative assessment of each student's construction of sophisticated Excel formulas is comprehensively facilitated via a purpose-built Excel workbook that records a student's attempts in relation to the production of a specific formula. This record is then analyzed by teaching staff who can then more accurately assess how a student is building knowledge and experience in the professional use of Excel. This in turn provides more relevant and accurate feedback to each student and also better informs ongoing teaching messages delivered to the total student cohort. In overall terms, the results indicate that students positively respond to the approaches primarily because of the increased personal autonomy of the audio/visual instructional content, and because of the increased level of dialogue created by the digitally facilitated formative assessment feedback.**

***Index Terms*—formative assessment, blended learning, end-user programming, Four Resources model, classroom video pedagogy**

I. Introduction

In this paper we describe an ongoing multi-year project to improve the learning outcomes for first year undergraduate business students within an Information Systems (IS) course. The IS course is a core unit within a Bachelor of Commerce degree program, runs in both semesters of each calendar year, and has very large enrolments (current semester 1/2018 enrolment of 1144 students). The first stage of the project reviewed and re-defined more precisely the learning outcomes for the students and the pedagogical framework for teaching a core component within the course: Excel end-user programming.

Manuscript received February 25, 2018; revised August 31, 2018.

The original motivation for the overall project was the goal to pedagogically manage the stark difference in results achieved by a majority of students in information system (IS) theory, as compared with student results in the practical analysis via Excel. In simple terms, the IS theory results were strong, whilst the Excel practical results were below expectation. This is very much the case regularly reported in the literature in relation to Excel and business students [1]. The continuing research within this project reveals that student attitudes to Excel end-user programming are quite pessimistic. Whilst all students readily appreciate the business results delivered by Excel, there are many students who consider the abstraction and systems-thinking of developing end-user programming and problem-solving as a "black box" – these students cannot see a clear learning path which may take them from beginner knowledge level to professional competency.

The pedagogical theory utilized for this first stage is the Four Resources Literacy Education model. This model allows teaching staff in our project to present Excel end-user programming as a new literacy for business students, a literacy that can be acquired via the structured program of knowledge building and application which is based on the Four Resources model. The Four Resources model is described in [2] and [3] as a normative, diverse-method (i.e. inclusive of many practices) literacy education model designed to apply across many disciplines (not just English courses). A description of this stage has been presented in [4] and [5] and will be summarized in Section 2 of this paper for completeness.

The second stage involved the development and delivery of additional scaffolding of pedagogical content via audio/visual (MP4) streaming/download, and this is described in Section 3. The most recent stage of our project comprises a trial in which formative assessment of the Excel formulas required to be constructed for the single major assignment (20% of overall assessment) within the course is facilitated via a purpose-built Excel workbook. This workbook records (i.e., captures) a student's attempts in relation to their attempt at deriving the specific formula. This record is then easily analyzed by teaching staff who can then more accurately assess how a student is building knowledge and experience in the professional use of Excel. In turn, this protocol provides more relevant and accurate feedback to each student and also better informs ongoing teaching

doi: 10.18178/ijlt.5.1.12-18

messages delivered to the total student cohort. This stage will be discussed in Section 4. Section 5 will conclude the paper.

II. Reviewing Learning Outcomes

The initial motivation for this project was an identified divergence of prior learning of students enrolling within a business undergraduate first year business course now titled "Transforming Business with Information Systems". Qualitative and quantitative analysis, discussed in detail within [4] and [5], confirmed that many students were enrolling with considerable prior Excel knowledge (not sufficient for awarding course credit), whilst many other students undertaking the course possessed little or no prior Excel knowledge. The other historically statistically consistent characteristics within the enrolment are that the male/female enrolment demographic is evenly split, class contact times comprise a 2-hour lecture (with audio/visual recording for subsequent streaming on-request by students via a content web server) and a 2-hour tutorial each week over the 13 week semester, and that approximately 50% of students do not have English as their first language. Initially the teaching staff agreed that the significant variations in Excel prior knowledge levels created difficulties that required mitigation and pedagogical management.

The project commenced with a detailed analysis of the learning outcomes for the course. The analysis produced two major learning goals for the course: *computer literacy* and *information literacy*. Computer literacy within the IS course is defined in terms of a person's capacity for purposeful and effective use of information and relevant communication technologies (ICTs) [6], together with the need to know how to use these ICTs for present and future learning and problem solving [7]. Information literacy within the IS course is defined as the ability to locate, evaluate, manipulate, manage and communicate information [8] and also to develop values and attitudes about knowledge and how it is used and shared [9]. Excel was affirmed as the major software resource associated with both literacies.

The teaching staff considered these two sub-goals as necessary but not sufficient for the pedagogical requirements of the course and its difficult operational context. Specifically the teaching staff required a proven pedagogical theory for the teaching of literacy by which broad learning outcomes for the course within each major weekly topic (not just the course overall) could be described as a framework of learning and assessment milestones – ranging over a competence spectrum from the achievement of basic first principles through to a sophisticated mastery of each weekly topic – and by extension, the course content overall. The teaching staff considered several literacy frameworks, including the definition in [9]: "we can think of literacy not merely as a single set of skills, but as a way of operating with a variety of texts within particular social situations…Literacy practices are embedded in the practices of our daily lives". Additionally the literacy description in [10] was persuasive: "There are school Literacies, computer Literacies, out-of-school Literacies, social Literacies and so on that are characterized by a wide range of written, spoken, aural, visual, digital, and multimodal texts". Whilst many literacy pedagogical models influenced the project, the most influential was the Four Resources Model for literacy education.

The Four Resources Model is described in a reflective essay [3] as a normative, diverse-method literacy education model designed to apply across many disciplines. The view in [3] is that literacy capabilities comprise three dimensions or '*lens*':

a) The *breadth* of literate practices contained within the curriculum – i.e. what kinds or genres?
b) The *depth* and *degree* of control exercised – i.e. how much?
c) With what *transformative* direction and power?

In the theory as described in [2] and [3], the *breadth* and *depth* of literacy practices can be reliably and validly measured within an education setting. In [11] the Four Resources model is described as a pedagogical framework for developing *depth* of literacy control along four necessary (but not individually sufficient) repertoires or practices – and this depth was adapted within our project to form the required framework of learning outcomes (i.e. a milestone spectrum from first-principles to mastery) as follows:

- *Code breaking* – the capability of students to understand Excel terminology and basic Excel theory components (e.g., referencing, data-typing, operator precedence)
- *Semantic competence/text participant* – a student's comprehension of Excel concepts (e.g., in-built functions and return values)
- *Pragmatic competence* – a student's comprehension and competence in successfully applying Excel concepts and formulas in solving sophisticated business problems (e.g., 'nesting' functions within user defined formulas)
- *Critical competence* – a student's ability to critique business intelligence problems and propose Excel solutions (e.g., Excel Solver solutions)

These overall learning outcomes – together with the framework (based on the Four Resources Model) for curriculum design, delivery and assessment – were then operationalized. The delivery was trialed to small groups of students by the course's principal lecturer, and then the qualitative feedback was evaluated by the methodology outlined in [12]. Full details of the analysis methodology and results are available in [4] and [5]. The trial was assessed to be successful and subsequently scaled up for delivery to the whole student cohort. This leads to the project's second stage which unfolded during 2011.

III. Additional Scaffolding Design

Detailed evaluation of the project to date was then undertaken during the following two semesters and 84 students provided qualitative feedback. This was coded and analyzed using the Glaser-Strauss' *constant comparison* method [12] to allow interpretive themes to

emerge. In this coding and analysis process conceptual categories are initially generated by a comparison between and across data observations - a category being an attempt to find a concept of a slightly higher level of abstraction than the data itself. The category itself labels a set of observations that describe the same phenomenon – the category is a separate element of a theory, that is, a concept [12]. Categories must be meaningful, that is, they should generate interest in, and assist understanding of what issue is being studied [12]. Whether or not a category is appropriate cannot be judged solely from the correctness of the underlying data – the usefulness of a category must be decided from its ability to contribute to the emerging theory. New data are constantly compared with evolving categories – with the ongoing generation of new categories. Comparisons between categories generate hypotheses, which are defined as categories related to one another [12]. The collection of data will continue until no further properties can be found or added to categories – a stage that [12] called theoretical saturation.

The analysis initially identified 9 top-level categories across the collected data set. Further analysis revealed overlap and redundancy and this in turn reduced the top-level set to 2. The final top-level categories and subordinate categories are shown in Fig. 1.

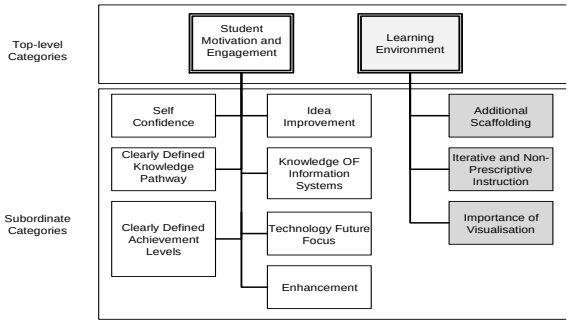

Figure 1. Stage 2 result categories

In Fig. 1, the category "Student Motivation and Engagement" and all its subordinate categories were a positive endorsement of the project to date. The category "Learning Environment" and all three of its subordinates (in grey fill) identified deficiencies within the project. It is this set of deficiencies that will be discussed in this section.

A total of 32 students (of the contributing 67) expressed comments indicating that they had had "under-achieved" in relation to advanced Excel spreadsheet theory and practice. Of this set of students, 15 commented that the 2-hour lecture and 2-hour tutorial each week were inadequate for them to achieve their learning goals with respect to Excel. Of the top-level set of 32, a total of 13 students indicated that the Excel text used for the tutorials within the course was too prescriptive and "like a cooking recipe" with "lots of instructions showing what to do". This group of students commented that they had completed all instructions in many parts of the set book without attaining the prescribed learning outcome. In addition, 7 students described the audio/visual recording of each entire (2-hour) weekly lecture to be of inadequate production quality for the 50% of each lecture that related to advanced Excel theory and practice. All 27 students heavily endorsed the concept of recording and streaming/distributing the lecture – it was the low quality of the recording that attracted their criticism.

Teaching staff immediately recognized three problems that required improvement before the recommencement of teaching. Firstly, the unattained learning potential indicated an unrealized proximal development zone [13] as represented in Fig. 2. A set of motivated, focused students had not attained their desired learning outcome with respect to 50% of the course's content (Excel theory/practice). This proximal development zone, in turn, pointed to the need for a scaffolding strategy [14] – that is, additional teaching support for students that fitted within the defined resourcing limits of the teaching school.

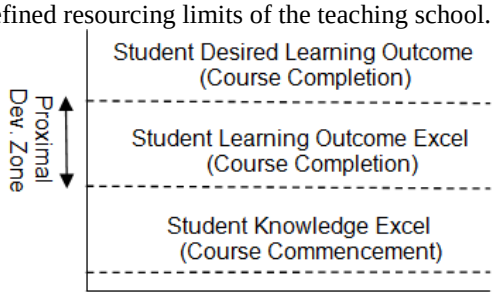

Figure 2. Zone of proximal development

The second feedback criticism from students had been anticipated by the teaching staff. Quite simply, the criticism centered upon simplistically written and very prescriptive textbooks in the course (Excel) area. The teaching staff recognized that this was not a reflection on author failings – it was the problem created by using a paper medium for transmitting educational content that was far better relayed by audio/visual demonstration and explanation. It would be advisable to consider the production of suitable videos rather than prescribe a new text book.

The third feedback criticism from students related to the production quality of the existing audio/visual recordings of all lectures. These recordings captured the screen display during the lecture, together with the audio commentary of the lecturer. This criticism had also been anticipated by teaching staff. To revisit Section 1, the weekly lecture comprised two halves: an IS theory component and an Excel theory/practice component. The audio/visual recordings were very good for the IS theory lecture each week, in which PowerPoint slides, short video screenings, and of course spoken commentary/explanation were all combined. The Excel component, however, did not capture well via the theatre recording technology. The screen display and capture resolution did not produce clarity in the final video. There was no capacity to introduce a zoom/pan production technique, and this presented difficulties in viewing-clarity and lecture emphasis. There was also no capacity to introduce callouts, highlighting, or text labels into the final produced video and this also prevented adequate emphasizing of important points during the lecture. Finally, if the lecture delivery time was not adequate for a

complete demonstration of the planned Excel curriculum for that week – the recordings were consequentially incomplete.

The teaching staff agreed a strategy to address all three students' criticisms – the in-house production of a series of Excel videos. This decision reflected a clear trend in tertiary education – the increasing use of digital video technology. This trend is now increasingly reported in several studies [15]-[17] as experiencing very rapid growth. Our project goal was to provide scaffolding for students, improve pedagogy, and reduce text book costs for students. A total of 12 Excel instructional videos have subsequently been produced. The central design decisions were as follows:

a) A PC-based screen and audio capture software package was selected. The package has a light-weight desktop processing footprint. It allows substantial video editing (e.g. zoom/pan, variable capture areas, callouts/highlighting (e.g. text and graphics). It allows substantial audio editing (e.g. separation of video and audio tracks, background noise removal)
b) In line with the structure provided by the Four Resources model, the videos would span 5 major content areas: (1) Excel introduction (e.g. formatting, data-typing, editing data, routine functions); (2) Excel built-in functions with a major focus on *lookup*, *decision making*, *statistics*, *database*, and *date/time* categories; (3) Excel charting/graphing; (4) Excel formula development (i.e. the composite use of built-in functions as a base for automating complex business process logic) and (5) Excel Solver for complex business intelligence analysis and solution. Each video would be aligned with an existing lecture and practical session.
c) The established learning outcomes (Section 1) would underpin the video content and production. Each video would clearly articulate a range of learning outcomes with clear milestones for each learning outcome (as per the Four Resources Model) for student knowledge/competency attainment.
d) Each video would use PowerPoint slides for the discussion of Excel theory and syntactic analysis of Excel functions. Each video would use spreadsheet development of solutions to authentic, business problems to demonstrate and explain Excel applications and its ability to automate business processes. Each Excel video would be approximately 20 - 30 minutes in duration.

The series of Excel videos were introduced into the curriculum of the course and made available to students via a (Blackboard) content web-server. The paper-based text for the Excel component of the course was dropped. A detailed analysis of the video/audio based scaffolding strategy was then undertaken during the next semesters. Qualitative feedback comments in relation to the video scaffolding were consistently requested and obtained. The qualitative analysis was completed using the same process as outlined in Section 3. The student feedback was very positive. A clear majority of students commented that the videos substantially reinforced the lectures and increased their level of understanding and their learning outcomes, and this reflects the findings expressed in [18]. Many students responded very positively to the visual and aural dimension of the videos, commenting that the combination of video exposition and oral explanation produced a rich learning outcome. This finding aligns very much with results reported in [19]. All students preferred (for Excel instruction) the audio/video production over a text book production.

IV. Further Analysis and Formative Feedback via Blended Learning

Quantitative analysis of student results was also completed over the next three semesters. This analysis revealed that overall student performance had significantly improved. In the major Excel assignment for the course, student performance had averaged 15.1% from a possible 20%. This increased across the next two semesters to 15.9% (the assignment problem scenario had remained unchanged in its degree of difficulty). However in the end-of-semester closed-book summative testing, Excel comprised 30% of the total available marks and the Excel questions mostly required a student to build a composite Excel function for the automation of common, however non-trivial business challenges (e.g., the calculation of personal income tax liability via a differentiated tax system as operates in Australia). Student performance before the pedagogical changes had averaged 12.8% of this overall 30%. This increased across the next three semesters to 14.1% (the teaching staff considered the examination questions had remained unchanged in their degree of difficulty). Further analysis of this data revealed significance variance in the results. Excel student performance comprised two dichotomized partitions – those students who were attaining (even exceeding) the learning outcomes – and those students who were still struggling. The teaching staff realized that there was an additional scaffolding strategy needed to assist this lower performing student cohort. This realization was the impetus for the current stage in this overall project – additional formative feedback during the semester on the topic of complex Excel formula construction.

A. Formative Assessment - Blended Learning

There was an immediate and unanimous starting assumption in relation to the new formative assessment protocol: it must operate within a *blended* learning environment. Quantitative analysis at an institutional (i.e., University of Queensland) level of on-campus student numbers per-day-of-the-week contrasted with content web-server access usage (by students) was a primary basis for this starting assumption. This analysis clearly shows that on-campus numbers during a routine teaching week are very substantial and that many students participate in *face-to-face* teaching – thus necessitating the teaching support for *face-to-face* teaching, including

feedback to students. However the number of student accesses to the content web-server used across the university (a Blackboard system) consistently exceed those students physically on campus. This is shown in Fig. 3. Additionally a University of Queensland survey of 5000 students revealed that 80% of students use the Blackboard content management system. This is the highest access statistic of any University or external service, exceeding web-mail (79%), Facebook (74%), university library database access, and YouTube (49%). This data confirms that University of Queensland students connect very positively with web-based curriculum content delivery. This is very much endorsing the findings in the literature review of [20], [21] which "observed two complementary movements in the educational landscape: the merging of online teaching and learning into the stream of everyday practices at universities, and the increasingly salient role of distance programs in institutions of higher education". Clearly, any new feedback protocol should fit within a blended learning environment.

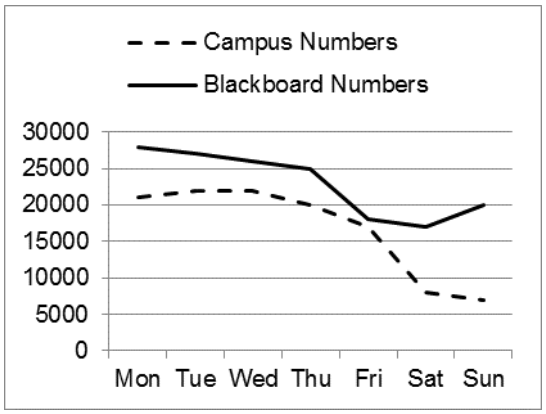

Figure 3. On-campus V blackboard accesses

B. Required Feedback Characteristics

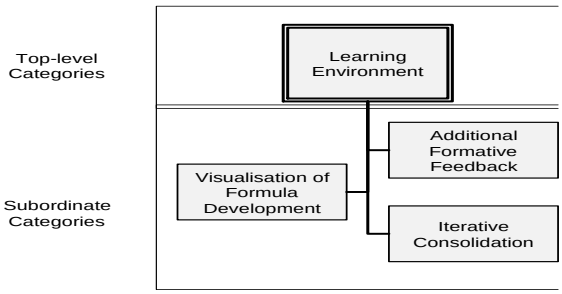

Figure 4. Further analysis categories

The next stage of the analysis involved interviews with teaching staff and a selection of students who had experienced difficulties in attaining the Excel formula development learning outcomes. The analysis of these interviews was completed via the *constant-comparison* methodology described in section 3 of this paper. The analysis pointed very clearly to teacher-student difficulties in relation to level three of the learning outcomes spectrum described in section 3 of this paper, that is: *pragmatic competence* (a student's comprehension and competence in successfully applying Excel concepts and formulas in solving sophisticated business problems, e.g., 'nesting' functions within user defined formulas). The analysis identified a single top-level category across the collected data sets (both from teaching staff and students). This top-level category and its subordinate categories are shown in Fig. 4.

Both the teaching staff and the students identified strongly that the blended learning environment required additional scaffolded teaching that should be targeted at the third level of the learning outcomes spectrum (of the Four Resources model) described in section 2 of this paper. This scaffolding strategy should address the following:

- Additional *formative feedback* for students and the feedback is available via a blended learning environment. The formative feedback should occur in time as close as possible to when the student completes the set task and must have the aim of supporting learning and building knowledge[20]-[22]. The formative feedback must elicit evidence about student achievement and this is also used to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions that would have taken in the absence of the evidence that was elicited [23], [24]. Online formative assessment is defined in [24] as "the use of ICT to support the iterative process of gathering and analyzing information about student learning by teachers as well as learners and of evaluating it in relation to prior achievement and attainment of intended, as well as unintended learning outcomes". In [25] a comprehensive literature review of the value and practice of formative assessment in online and blended higher education is provided. This review identifies only 18 empirical studies "drawn from a wide range of publications in Europe, Australasia and North America". This "paucity of studies" is available from a narrow discipline spread where "half of the selected studies were teacher education courses". The review suggests that further empirical research about online formative assessment via a systematic and rigorous approach is required in order to achieve useful findings that can inform effective practices, and that "one way forward would be to conduct research within real-world contexts that focuses on in-depth investigation in the design and embedding of formative assessment within online courses".
- Visualization of formula *development* must be available to the teaching staff and the student. This means very clearly that all working by the student in the overall development of the Excel formula must be captured and retained. Teaching staff repeatedly spoke of the difficulties in seeing just the two end-points: (1) the specification of the set task and (2) the final submitted answer by the student. That is, teaching staff required (if possible) to see all the working *between* the two end-points.

Teaching staff required "a record of a student's thought trail – some indications of how the student had unpacked the specification and then proceeded to build the required formula". This would provide teaching staff with a much clearer picture of the knowledge level of a student and also their appreciation of the logical development of a solution.

- The formative feedback should provide for the iterative consolidation of the set task. That is, the overall process should be part of a formative feedback loop, and this loop should finally produce genuine knowledge building on the part of the student. Teaching staff stressed that the formative feedback should enable students to incrementally build their solutions. In this way, crossing the zone of proximal development (too large for many students to effectively traverse via conventional teaching methods) could become more attainable by students.

C. Formative Assessment Protocol Design

The teaching staff required a formative assessment protocol that would satisfy three high-level requirements: (1) the protocol must operate effectively in *face-to-face* and *online* modes, (2) the protocol would communicate to students an individual problem specification (i.e., a specification of a high-level business problem requiring an Excel formula solution), (3) the protocol, when engaged by a participating student, would capture *all* student working in building the specified Excel formula, (4) the capturing and recording of all student working should not be explicitly visible to the student using the artifact – however the protocol should advise the student that the data capture is being undertaken, and (5) the teaching staff can easily retrieve, via the protocol, all captured student working, and in turn use this working to assess student progress and deliver feedback to the student.

The teaching staff decided that the protocol requirements described above would require the design and construction of a generic Excel workbook as the formative assessment *artifact*. The project management methodology adopted for this design and development was informed by the design science work of [26] which "addresses research through the building and evaluation of artefacts designed to meet the identified … need".

D. Excel Artifact Description

In the second half of 2017, the teaching staff developed an Excel workbook file containing VBA programming designed to record all attempts and all related actions relating to the attempts (i.e., student attempts at formula construction. Each time a formula is entered (either fully or partially, either correctly or incorrectly) into any cell, a recording action is triggered within the workbook. This event (operationalized via hidden VBA code) records the reference of each cell changed, the formula (or partial formula or data) entered into the cell(s), the Excel return value of the formula, and a time stamp identifying the moment of change. Other events of interest, such as switching between the instructions worksheet and the task worksheet are also be recorded.

These changes are recorded on a logging worksheet within the overall workbook. This logging worksheet is hidden from the student and only viewable by teaching staff. Of course, the student using the worksheet is fully advised that the log worksheet is being continually updated with all student actions during their attempt at Excel formula construction. However for all other purposes, the workbook has the "look and feel" of a routine Excel artefact, and this serves to avoid distraction or confusion to the participating user.

The Excel workbook is then returned to teaching staff (either online or face-to-face). The teaching staff quickly access the logging worksheet and that immediate access to understanding the logic (correct or otherwise) used by the student to progress their solution. The logging worksheet enables the teaching staff to feedback a high quality critique to the student, even with respect to how quickly the student answer was derived.

V. Conclusion

This paper outlines the ongoing efforts to improve the teaching of advanced Excel theory and practice to first year business degree students. To date, these efforts have produced significant improvements in student engagement and learning outcomes. The latest strategy combines the benefits of formative feedback and blended learning to facilitate students and teaching staff in achieving knowledge construction in the specific domain area. The latest strategy (and indeed the overall combination of strategies) has been trialed on a limited basis during the second half of 2017 and will continue to be tested and evolved during 2018.

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