Design based research to create instructional design templates for learning objects

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1. Introduction

Educational research problems involve observing multiple interacting variables and multiple stakeholders. Educational research often involves the development of artifacts. Researchers not only develop interventions but also observe the process of developing and implementing these interventions (Johnson & Christensen, 2004), and devise principles or theories related to these processes.

One such educational research problem is the process of creating learning objects (LOs). Learning objects (LOs) have become valuable teaching and learning tools in a variety of instructional contexts (Bratina, 2002, Boyle, 2003, Wang, 2008). Creation of LOs involves multiple interactions between stakeholders from various domains such as the subject matter, instructional design, visual communication and software development (Weerasinghe, 2007). During the LO creation process, templates are used to generate products such as Instructional design document, storyboard and animation design document, which facilitate the interaction between the stakeholders. To make the process more efficient, the templates need to be iteratively refined and tested. The research method chosen to address this problem should facilitate the observation of the interactions between multiple stakeholders and the iterative testing of the products.

Design based research (DBR) is one such research method, which can address multiple interacting variables and allow for iterations of the intervention until it becomes effective. DBR is "a systematic study of designing, developing and evaluating educational interventions (like programs, teaching-learning strategies and materials, products and systems) as solutions for complex problems in educational practice. It also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them" (Plomp, 2007). Iterative development of interventions based on summative evaluations is a characteristic of DBR.

In this paper, we explain the key features of DBR, various DBR models, and also how it is applied to the ID template creation problem mentioned earlier. Section 2 details out the educational research problem of ID template for LO creation. Section 3 discusses the characteristics of DBR followed by section 4 which compares a few DBR models in detail. In Sections 5 and 6, we revisit our problem, and argue how one of the DBR models (mentioned in Section 4) is suitable to be adapted for our research problem. We also present the rationale for the adaptation of the existing model. Section 7 has the implementation methodology we follow, to complete first iteration of the intervention. We conclude by a discussion on the results of the first research cycle and discuss the future work in section 8.

2. Overview of our problem

A generic process followed for LO creation involves multiple stakeholders (see figure 1) from diverse professional and specialized fields. They are: subject matter expert (SME) who is the proposer of the topic for creating a LO; instructional design expert (ID expert) and visual communication expert (VC expert), who decide the strategies for instructional design and visual communication respectively. The team also consists of instructional designers (IDs) and the graphic designers (GD) who implement the

pedagogical and visual approaches decided by the ID expert and VC expert respectively. In the end, the animators do the programming to create the LO (Sahasrabudhe et al., 2012).

The SME proposes the LO topic using a concept selection form (CSF). The Instructional Design (ID) and the Visual Communication (VC) experts discuss about ID and VC strategies to be incorporated in the LO. These guidelines are communicated to the instructional designer, who creates an instructional design document (IDD), for the Graphic Designer (GD) to create a storyboard of the LO. Finally, the animator creates the LO using the storyboard and the IDD. The grey dotted lines in the figure denote the requirement of the face-to-face interaction on a certain decision.

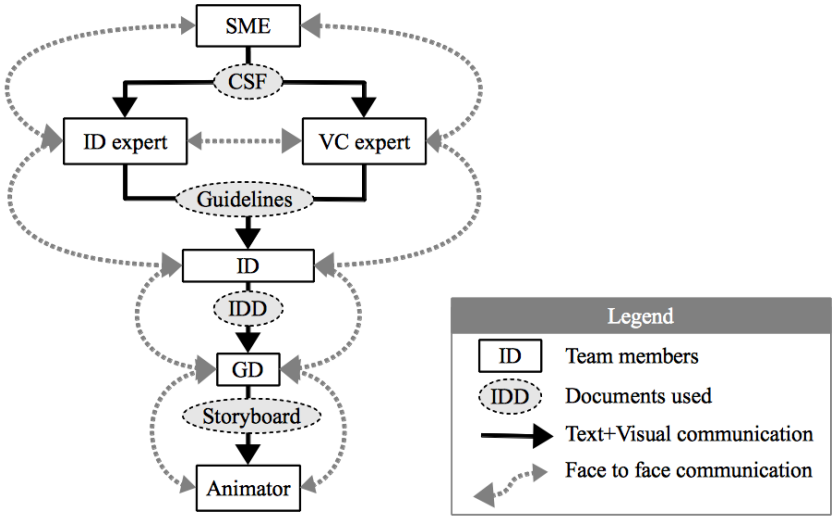

Figure 1: Generic LO creation process showing the interactions and the documents used for communication between the stakeholders [Sahasrabudhe et al., 2012]

Templates help in achieving clarity and similarity in the process flow. However, apart from other communication, the communication between instructional designer and animator is a commonly known problem (Boot, E. W., et al, 2007), (Boot, E W., et al, 2008). The reason for this is that this stage of the process has the transition from textual content to visual/animated content.

Our goal is to reduce the dependency of the face-to-face interaction specifically between the VC experts, instructional designers and the animators. Typically, the instructional designers use instructional design template (ID template) for creating instructional design documents (IDDs) to communicate with the animators. VC expert provides face-to-face input to both the instructional designer and the animator on the visuals in the IDD. Our objective is to capture the expertise of the VC expert within the ID template itself. We achieve this by studying the decisions taken by VC experts, understanding the principles behind the decisions and operationalizing the principles in the form of prompts and guidelines in ID template. We expect that this enhanced template will not only make the ID documents more usable for the animators, but also have reduction in dependency of the face-to-face interactions.

However, it is likely that a single level of modification in the ID template may not be enough for getting the desired results because of the multiple interactions between the various stakeholders at different stages of LO creation. The modifications involve refining the ID template, by applying and operationalizing different VC principles. This refinement can be done on the basis of systematic evaluation at every stage of implementation. Since this is an iterative process, we need a research method like DBR which enables us to do so.

3. Characteristics of Design Based Research

In a research study, the initial intervention may or may not have effectively solved the problem. In design based research (DBR), if the intervention applied is not found to be effective; one can iterate the intervention until it becomes effective. Each iteration of modifying the intervention is termed as a research cycle. The important aspect of DBR is that the outcome/s of every research cycle is used as input for the next research cycle (see Figure 1). This helps in augmenting the intervention on the basis of the 'failures' in the earlier research cycles.

The cycles conclude after a particular version of the intervention shows desired results. In DBR, the conclusions of this process not only have the detailed log of the chronological development of the intervention but also the documentation of the problems recorded in the earlier cycles (along with the steps taken to address them).

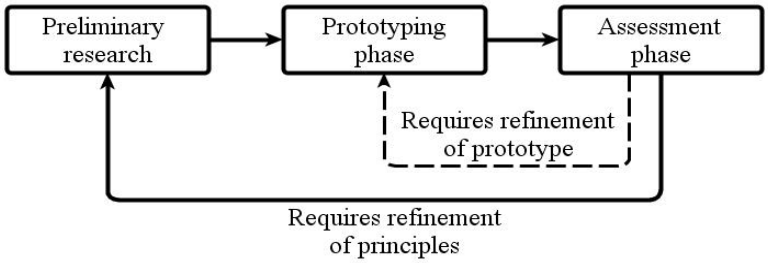

Figure 2: Cyclical process of DBR for creating a prototype by analyzing the results

There are three phases in implementing DBR:

- Preliminary research: In this phase, need and context analysis is done in the beginning. This is followed by review of the literature regarding the domain. These two sub-stages are useful in formulation of a conceptual framework for the study, leading to the choice of principles to be applied for addressing the problem.
- Prototyping phase: In this phase, products/artifacts are created to address the problem. Context analysis and the focused review of literature provide the necessary scaffolding to choose appropriate principles for creating the product/artifact. Further, this product/artifact is applied to the problem.
- Assessment phase: In this phase, the intervention is evaluated to see if it addresses the problems and gives the desired outcomes. This is called as Semi-Summative evaluation phase (Plomp, 2007). The results of this phase may be in the form of recommendations or guidelines for the improvement of the intervention or solution.

At the end of these phases, theories and principles (found effective) are published as a contribution to knowledge.

There exist several models and approaches in which DBR is implemented. Each model typically has the three phases described above. Each model addresses a particular problem in educational research and has its own characteristics. In order to choose a DBR model which can be useful to address our problem (overview mentioned in Section 2, and with details in section 5) we review four DBR models published by various researchers, in the next section.

4. Comparison of DBR models

We study four different models of DBR implementation in order to design a suitable model to address our problem. This comparison enables the understanding of various approaches and elements used by

researchers for different educational research problems solved using DBR. The subsections below provide details of each DBR model, the context of applicability, and the research problem they address. We analyze each model in terms of what is done in each phase of research (preliminary, prototyping and assessment phases), and the corresponding outputs. For each model, we also discuss which elements in the model are suitable for our research. At the end of this section, we compare the DBR models and choose the one which has most of the necessary elements to address our problem.

4.1. Reeves (Reeves, 2000):

The generic approach of DBR presented by Reeves is shown in Figure 2. Unlike other models (for example, models described in Sections 4.2, 4.3, and 4.4), Reeves' model is not intended to solve a specific design problem at hand. Instead, Reeves' approach captures the main features of a typical DBR process and presents a generic approach of implementing various stages of DBR. This approach can be considered as an overview to understand specific DBR models. Hence we begin our comparison of DBR models with Reeves' overview approach.

This approach has four stages (figure 2), which are common in other DBR models. The feedback from every stage is shown using the vertical arrows. The features and stages of this model are outlined below.

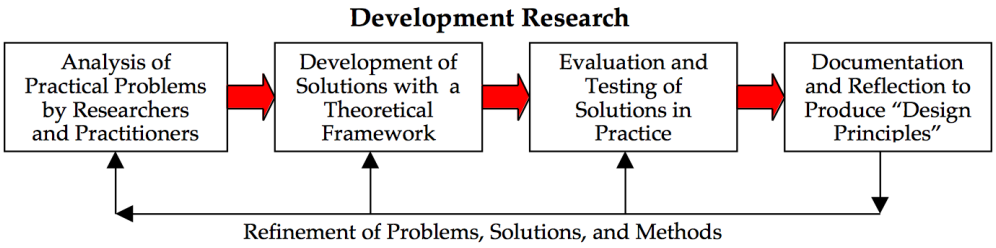

Figure 3: DBR approach presented by Reeves showing four stages

- Analysis stage: Practical problems are analyzed by researchers and practitioners in collaboration. This unique feature of DBR is the first stage of this approach. This provides necessary context to the researchers in development of solution for the given problem.
- Development of solutions: Existing principles and theories are referred to create a solution for the problem documented in the analysis phase. The ongoing innovations in the technical field are also considered while designing the solution.
- Iterative cycles of testing: Cycles of testing are carried out for refinement of solutions in practice. Data collection and analysis (corresponding to the research questions of the study) is carried out. Based on the analysis of the data collected, the intervention is refined, and tested again. There could be multiple such cycles before the feedback shows that the intervention is found useful.
- Reflection of the feedback from users: The refined intervention is tested by the users and the feedback is collected. The principles applied in creating the final version of intervention, are then documented to produce 'design principles'. These principles can be used by researchers in future to enhance the implementation of the solution.

The aspects of Reeves' approach that are useful for solving our problem are: refinement of problems, solutions and methods at every stage of DBR. However, Reeves' approach does not provide the details of the process of conducting the research cycles. For example, it does not comment about the elements such as number of samples or expected timeline for the process. It is therefore necessary to study other DBR models and see if those models provide information about the missing elements.

4.2. Wademan (Plomp, 2007):

Wademan's DBR model addresses the development of interventions to help decision makers on whether and how to utilize the People Capability Maturity Model ® (People CMM ®). It is an approach to attract, motivate and retain talented human resource, amidst the increasing competency in the business sector. The goal of this approach is to analyze the problem, and provide insights to the decision makers regarding adoption of People CMM. Wademan's model addresses this problem, and aims to advance the knowledge base and theory in People CMM.

Wademan's model defines the stakeholders at various stages, their respective roles and the interaction between them. The stages of the model are explained below. Summary of this can be seen in the Figure 3.

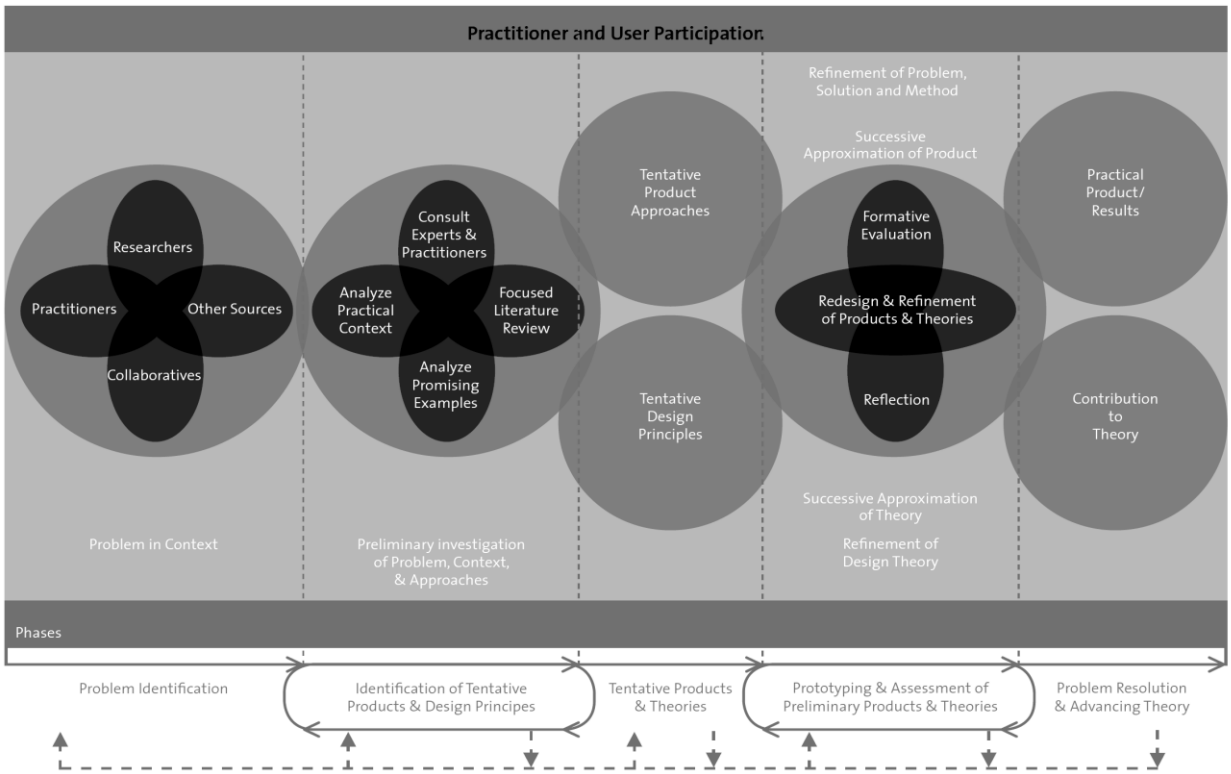

Figure 4: Wademan's model for DBR showing five stages and iterations shown below

- Problem Identification (Researchers, Practitioners, Collaborative and other sources): In this phase, the context is studied to identify the problem. Companies experience lack of accessibility, and other relevant information about People CMM. This restricts the usage and hampers its utilization for workforce enhancement. The stakeholders interact with each other and determine the gaps.
- Identification of Tentative Products and Design Principles (Experts and practitioners who need to use People CMM): After the problem is identified, preliminary investigation of problem, context, and approaches is done in consultation with the experts and the practitioners. This is supported by conducting focused literature review, and analyzing practical context. Promising examples, which represent the problem, are analyzed. This process helps in identifying tentative list of products and design principles to be applied in the study.
- Applying tentative products and theories (Researchers, practitioners & end users): Tentative products are created using the tentative list of design principles. These are introduced to the users and the results are captured.
- Prototyping and Assessment of Preliminary Products and Theories (Researchers, practitioners & end users): Redesign and refinement of the problem, solutions (created in stage 3) and method is done based on the feedback received in stage 3. Formative evaluation is used along with the reflection of the

feedback, to do the redesign and refinement. This is an iterative stage where, the refinement is done for achieving successive approximation of theory, and refinement of design theory.

- Problem Resolution and Advancing Theory (Researchers and end users): Practical products are created, after the iterations conducted in stage 4. These products have certain aspects, which contribute to the existing theory.

The model has loops at some stages (for ex. Identification of principles and prototyping stages), which are used for refining the intervention. Unlike Reeves' model, refinement is not done using a feedback loop, but is done in a separate stage. The detail of the stakeholders at every stage is an important aspect of Wademan's model. This is useful for our research problem of LO creation, as there are various stakeholders in this process, at respective stages.

4.3. **McKenney** (McKenney, 2001):

McKenny's model is used to explore the potential of computers for development of curriculum material. This study is the context of secondary level science and mathematics education in southern Africa. DBR is used to create an intervention, titled CASCADE (Computer Assisted Curriculum Analysis, Design and Evaluation). The research design (see figure 4) consists of three main stages given below:

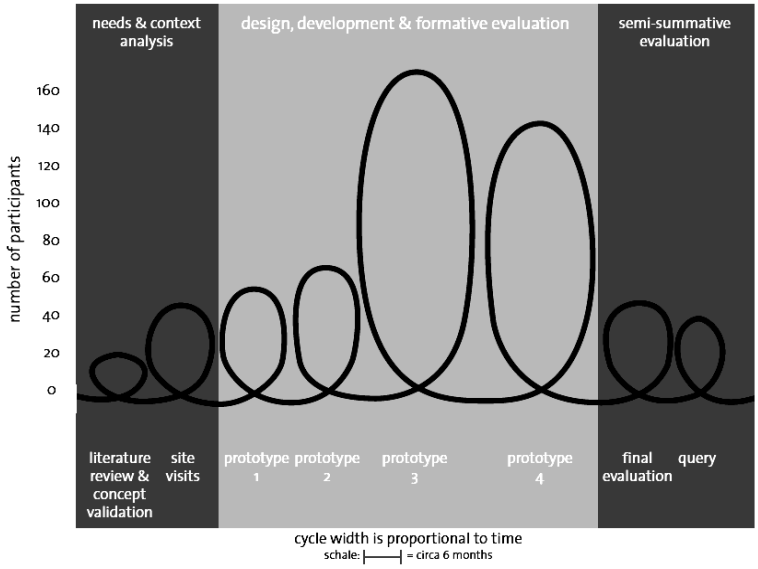

Figure 5: McKenney's DBR model with a graph showing the number of participants

- Needs/context analysis: Exhaustive literature review helps in the development of the tool. The review is about curriculum development, professional development of the teachers, existing exemplary materials and support structures including computer-based support. The themes of the literature review provide the necessary insights to shape the structure of the study as well as the CASCADE program itself.
- Design/formative evaluation of prototype tools: This stage has creation and testing of prototypes, with the users. Four prototypes (using the feedback of the participants) are formatively evaluated during this stage. It can be seen that the number of participants are less initially, and grow at later iterations.
- Summative assessment of the final product: This stage involves the final evaluation of the prototype. It also involves the reflection to produce design principles, which enhance implementation of the solution in practice and in future.

The result suggests that CASCADE system assists users in producing curriculum materials. These materials are found to be more effective than other materials created without CASCADE. The research

also contributes to the articulation of design principles and related development research methods applied in creating CASCADE.

The unique features of McKenney's model are specifications of timeline as well as the number of participants. As seen in the model, the number of participants increases gradually till the penultimate prototype is created. The number slowly reduces after the test for the final prototype and final evaluation is conducted. The availability of these details is important from the point of view of our research problem, to plan our studies. However, McKenney's model does not mention details about the stakeholders in various stages like that of Wademan's model explained in section 4.2.

4.4. **Mafumiko** (Plomp, 2007):

Mafumiko in his dissertation has focused on usefulness of Micro-scale chemistry experiments (MSCE). This is a unique way to explain chemistry as the experiments are on a reduced scale, and use small quantities of chemicals and simple equipment. The aim of his study is to design and evaluate an intervention (MSCE) to support curriculum material, and contribute to the improvement of teaching learning of chemistry. The research design used is based on DBR (see figure 5), and has three stages:

- Front-end analysis: This involves the literature review and the context analysis of the chemistry education in Tanzania. Literature review focuses on improving practical component of science education in various countries. Context analysis studies the models of teaching practical chemistry within Tanzania. Experts in the similar field of MSCE are consulted in this phase, which adds value to the front-end analysis. Initial design specifications are ready at the end of this stage.
- Design and formative evaluation of exemplary curriculum material: Cyclic approach of design and formative evaluation is used for creating the intervention. The evaluation provides empirical evidence of the practicality of the intervention. Successive versions of the materials evolve in to the final intervention. The model has stakeholders, who inform their feedback through the formative evaluation. These stakeholders are experts, students and teachers. This feedback is useful to modify the intervention.
- Summative evaluation of intervention (MSCE): This is carried out by conducting a field test of the final intervention. This stage demonstrates actual practicality and the effectiveness of the intervention.

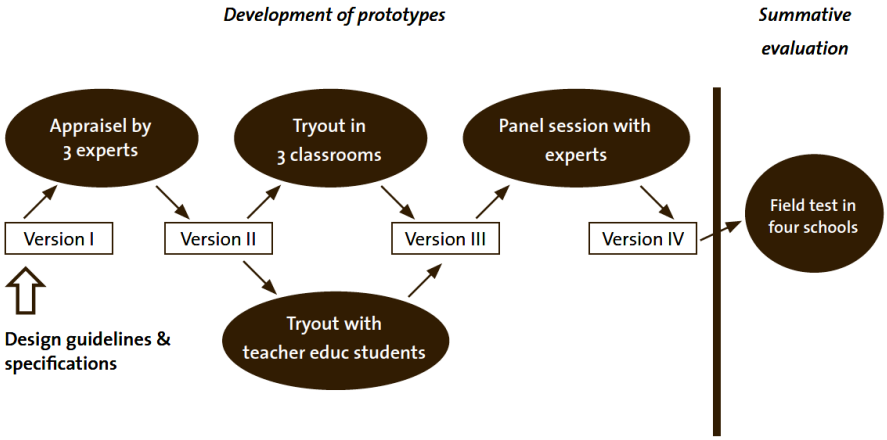

Figure 6: Mafumiko's DBR model with an emphasis on prototyping phase

The unique feature of Mafumiko's model is the process followed in the prototype development stage. The iterations are performed by collecting feedback from experts and users alternatively. One can also see that the number of respondents is small (for example, three experts for appraisal of version 1). However, the researcher does collect feedback during four such versions (iterations), thereby managing a critical mass

required for validity of the feedback. It is also seen that the final evaluation is done using a larger sample (for example, field test in four schools).

Mafumiko's model shows the various stakeholders and their roles at respective stages. This feature can be adapted for our research problem, where we have multiple levels of users, for example Instructional Design writers use the ID Template created, and create ID Documents, which are then used by animators. However, the model does not elaborate about the first stage of formulating design guidelines to be adapted for creating the first prototype, like the way it is shown in Wademan's (section 4.2) and McKenney's model (section 4.3).

4.5. Comparison of DBR models

In sections 4.1 to 4.4 we described the features of different models of applying DBR. We analyzed the stages of research and the outputs in each model. Table 1 shows a summary of the features in the models.

Table 1: Comparison of stages in various DBR models

Reeves (2000)	**Wademan** (2007)	**McKenney** (2001)	**Mafumiko** (2007)
Stage 1. Preliminary research			
Analysis by researchers and practitioners	1. Preliminary investigation 2. Practitioner participation	1. Need/context analysis 2. Literature survey	1. Literature survey 2. Context analysis 3. Consultation with experts
Output of stage 1			
Practical problems are analyzed by researcher and practitioners	Context analysis by researcher, experts and other sources	Exhaustive literature survey which provide insights for the design of intervention	Focused literature review, detailed context analysis and expert opinions provide rich inputs for the development stage
Stage 2. Prototyping			
Development of prototypes	Successive approximation	Design and formative evaluation	Design and formative evaluation
Output of stage 2			
Developed Intervention	Developed Intervention	Developed Intervention	Developed Intervention
Stage 3: Assessment			
Iterative cycles of testing	Reflection	Summative evaluation	Summative evaluation
Output of stage 3			
Final prototype emerging out of the iterative cycles of creation, test, and modify	Final prototype after design and refinement based on the users feedback	Final prototype based on multiple cycles of feedback from the users	Final prototype with feedback from stakeholders and empirical evidence of its practicality
Stage 4: Contribution to knowledge			
Reflection of feedback from users	Theoretical contribution	Articulation of design principles	--
Output of stage 4			

Design principles which can enhance the implementation of intervention	Insights and models relating to the areas People CMM, design theory and practice, and Development Research	Theories articulating design principles and development research methods related to it.	Not mentioned
Overall outputs			
Problem analysis	Contextual analysis	Exhaustive literature survey	Focused literature review
Empirically tested intervention	Empirically tested Intervention	Empirically tested intervention	Detailed context analysis
Design guidelines	Models	Insights on design principles and development research methods	Final intervention with empirical data
	Insights related to the subjects		

The models created by various researchers have some common features, as well as a few differences. The differences in the features help us understand the suitability of a model in solving a particular educational research problem. All models demonstrate the parallel creation process of prototyping of interventions and finalization of design principles. DBR consists of three main stages. These are:

a. Preliminary research
b. Prototyping stage
c. Assessment

Almost all models have these three stages. However due to different terminologies used by the researchers, some stages are titled differently. For example, 'Problem Resolution and Advancing Theory' in Wademan's model resembles 'Reflection of the feedback from users' of Reeves.

All models address educational research problems, but the emphasis on the stages varies in some models. For example, in Wademan's model, preliminary research stage has equal importance as compared to the prototyping stage. However, in McKenney's model it can be seen that the emphasis for the prototyping stage is almost double that of preliminary research stage. This variation in the emphasis can be attributed to the goals of the research. Some models start directly with the prototyping stage, and combine the problem identification with that. For example: In Wademan's model there is a well-defined stage for 'problem identification', however, Mafumiko's model starts with a prototype based on the 'design guidelines and specifications'. All models have similar types of stakeholders such as, experts, teachers, students and practitioners as categories of stakeholders in their respective stages.

Our goal in comparing these models is not to conclude whether a particular model is better than other one. On the other hand, our goal is to compare the features of the models to help us in applying a particular model or adapting features of multiple models to address our problem. Table 2 compares the features of each DBR model such as, different stakeholders and their roles, sample size corresponding to the timeline and iteration levels, from the point of view of designing a new model to be applied to LO creation problem.

Table 2: Comparison of the features of DBR models

	Reeves (2000)	**Wademan** (2007)	**McKenney** (2001)	**Mafumiko** (2007)
Features	• Proposes refinement of problems, solutions and methods at every stage of DBR. • Refinement of intervention is done through the feedback for every stage • Does not provide clarity on the process of conducting the research cycles. Ex: number of samples or expected timeline for the process.	• Mentions the stakeholders at different stages. • Shows the loop in the process at some stages (for ex. Identification of principles and prototyping stages). • Refinement of the intervention done in a separate a separate stage. • Lacks information about the sample size and the timeline to be followed	• Specifies timeline as well as the number of participants (sample size). • Number of participants increase gradually till the penultimate prototype is created. • Number of participants reduces after the test for the final prototype and final evaluation is conducted. • Does not mention the details about the stakeholders in various stages	• Shows the various stakeholders and their roles at respective stages. • Does not elaborate about the first stage of formulating design guidelines to be adapted for creating the first prototype

5. Our research problem and solution approach

Out of the various definitions of a Learning Object, the one which considered in this research is "the smallest independent structural experience that contains an objective, a learning activity and an assessment" (L'Allier, 1997). As we have described in Section 2, the creation process of LOs involves multiple interacting stakeholders at various stages. In order to address this problem, ID templates provided by various authoring tools are used to create ID documents (IDDs). These IDDs are found useful to a certain extent since they provide ID guidance to novice animators (Chapman, 2008). However, the animators are unsure of the subject matter details required in the final LOs. For this, they are dependent on the face-to-face interactions with the IDs for understanding of the content. ID templates also lack VC information required by the animators. This adds to the animator's dependency of face-to-face interaction with IDs to get clarifications on the subject matter, ID and the VC strategy planned for the LOs.

The instructional designer-animator interactions are iterative, in order to perfect the content, design, interaction and usability. These iterations hereby slow down the LO development process. Absence or lower number of the interactions may lead to incorrect or non-usable LOs.

5.1. Goal of our research

The goal of our research is to address this problem of lack of VC information in the IDDs, which increases the dependency of the face-to-face interactions between ID and animator. We hypothesize that augmenting the ID templates based on VC principles would make the IDDs (created using modified ID templates) more usable for the animators, since they will have more (necessary) information present in the IDDs. The intervention (modified ID template) should ensure higher usability of: i) the ID template for the instructional designers, ii) the IDDs created using the modified template for the animators and ii) the LOs created using the IDDs for the LO users (students or teachers).

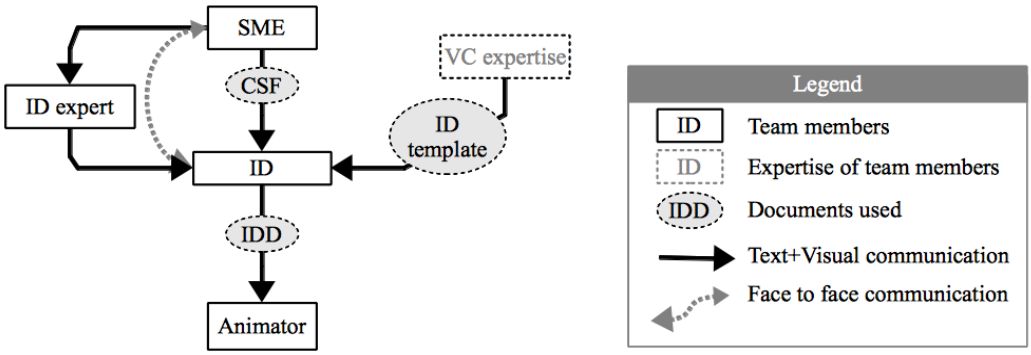

Figure 7: Goal of our research: Reducing the dependency on the VC expert, by adding the VC principles in ID template [Sahasrabudhe et. Al. 2012]

We also hypothesize that increase in the usability of the IDDs would result in reducing the dependency of the face-to-face interaction between IDs and animators. This in turn would also attribute in reduction of resources like time, cost and personnel required for LO creation. In order to achieve this, the intervention we plan to create and test is a modified ID template.

5.2. Our solution approach

In order to achieve the goal mentioned above, we used DBR process to refine the ID template (see figure 8). We focus on the ID template since this is the key document used to convert textual data to visual form.

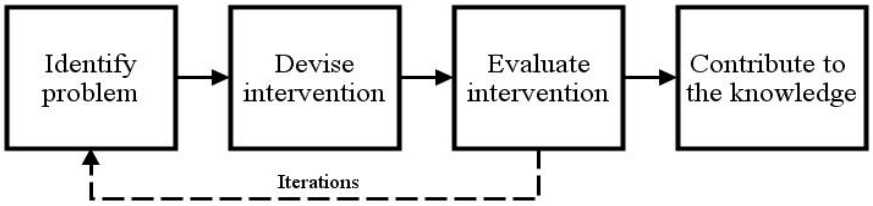

Figure 8: Solution approach for the ID template creation process

In each iteration, we first identify the problem with the template currently in use (during the previous iteration) by obtaining feedback from the relevant users during that iteration. We then devise our intervention, which is a modified version of the template based on the application of visual communication principles. We evaluate the modified template and iterate the process. The iterations are continued until the evaluation results show that the ID template is usable by all users – instructional designers, animators and LO users. After the intervention (the modified ID template) is established to have high usability, we devise guidelines of selecting the visual communication principles and the procedure of applying them to ID templates.

6. Applying DBR model to our research problem

We first summarize the features of our problem to be considered, and then show that Wademan's model is appropriate for our problem. We then describe details of implementing Wademan's model in our problem.

6.1. Features of our problem

Complex nature of the context
The context for our research is the process of creating learning objects on a large scale. This process involves multiple stakeholders who contribute at various stages. The communication / information flow is crucial in this process. This makes it complex, as there are multiple interactions between the stakeholders at various stages.

Iterations to create and validate interventions
Our research is not based on 'create once and use' format. The modifications in the intervention are done based on the feedback from the relevant users, and visual communication principles are applied accordingly. This modification is validated and the feedback used as a starting point for further modifications.

Possibilities of adapting this research for creating LOs in future
Our research is about content creation process. The process has to be such that it should be useful for future LO creators. In order to make it usable, it is important to use a method of 'apply-test-record'

Multiple interacting variables
Following variables in this study interact with each other and are dependent on each other. For example, change in the 'educational background of IDs' can change the 'dependency of the face-to-face communication between the stakeholders'.

- Educational background of the ID writers: Graduate level education. Additionally, a postgraduate level education in ID is desirable.
- Work experience of ID writers: Work experience of 6-10 months of ID for an educational institution or in an eLearning production setup.
- Educational background of Animators: Graduate level education in design/animation. Additionally, a postgraduate level education for the animation software (~1 year) is desirable.
- Work experience of animators: Work experience of 6-10 months of animation for an educational institution.
- Face to face communication between the stakeholders: Less or no face-to-face interaction between the team members producing LOs.

6.2. Rationale for selecting Wademan's model

Out of the four models mentioned in the section 4 (DBR models), the model chosen for this research is the one by Wademan in (Plomp, 2007). The rationale for this decision is given below:

1. Stages of Wademan's model coincide with the requirement of this research. That makes it easier to adapt Wademan's model to our research compared to other models which do not have similar stages (for example: Identification of tentative products and design principles stage is missing in Mafumiko and McKenney)
2. The stakeholders mentioned in Wademan's model coincide with the stakeholders of our research, but are not present in other models. However, these are not present in some models. For example, practitioners are not present in in Mafumiko's model.
3. Equal emphasis is expected on the preliminary research and prototyping stage of our research, as prescribed in Wademan's model. Models by McKenney (where prototyping stage has most emphasis), or Mafumiko (where prototyping has most emphasis) have emphasis on other stages.

Based on these arguments, Wademan's model was chosen for this research. However, the model cannot be adopted as it is and has to be modified to suit the requirements of this research. These modifications are shown in figures 9 and 10.

6.3. Adaptation of Wademan's model to our problem

In our model, we have three phases for the implementation of the solution (figure 8). Each phase contains four identical stages. These similar stages are designed in a particular manner wherein the output of the last stage (of a phase) is the input to the first stage of the next phase. This is common to all the phases. It is because of this feature, that the phases of DBR are often termed as 'research cycles'. The phases (research cycles) of our model (see figure 9) are:

1. Identification of the problem (research cycle 1): In this phase the communication between the ID and the animator is identified. Generic ID template is used to create the first version of the intervention (IDT1). This ID template is used to create IDDs, which are tested by the animators (who use those IDDs to create animations) for the usability aspect. The review of the IDDs is recorded for the second phase
2. Modification of the intervention (research cycle 2): The feedback of the animators is analyzed and the ID template is modified further to create IDT2. The ID writers use IDT2 and create IDDs. In this phase, feedback is collected also from the ID writers. Similar to the earlier phase, these IDDs are again tested by the animators for their usability. Their feedback is collected at the end of the phase.
3. Refinement and final evaluation (research cycle 3): In this phase, IDT3 is created based on the problems identified using the feedback of IDT2. Later, ID writers create respective IDDs using IDT3. IDDs thus created are then given to the animators for creating LOs. In this phase, feedback is collected not only from ID writers and animators, but also from the actual users.

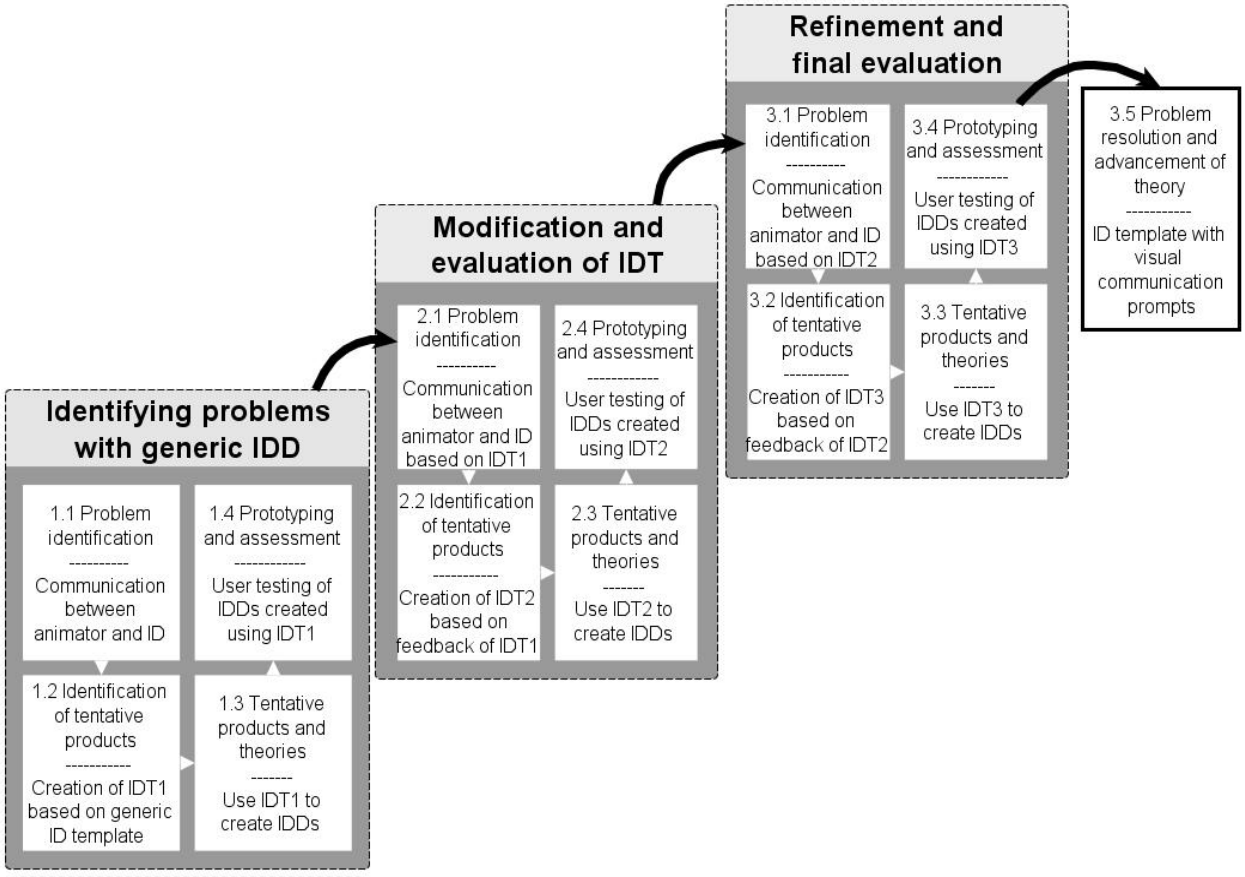

Figure 9: Overview the phases in DBR implementation for our problem

As mentioned earlier, each research cycle has four stages. These stages are:

1. Identifying problem: Analyze the feedback gathered in order to pinpoint the problem emerging out of it.
2. Identifying tentative products: Once the problem is defined in stage 1, a tentative product/artifact/intervention is identified which can address the problem. This could be tentative.
3. Prototyping tentative products: Once the tentative intervention is selected, then a prototype is created to be tested.
4. Testing the product: In the final stage, the intervention is tested with its respective users and the data is collected. This data is useful for identifying problem stage in the next research cycle.

Our adaptation of Wademan's model includes the following characteristics:

1. The flow mentioned by Wademan has loops at the 'identification of tentative products' and 'prototyping' stages. We have applied Wademan's model to our research problem with 3 loops or research cycles. First two research cycles are the loops of stages 1-4 (only, and not the fifth one about contributing to the theory) as mentioned by Wademan. However, the third research cycle has the 5th stage mentioned of contributing to the knowledge assuming that the usability feedback about the intervention (ID templates) is found satisfactory.
2. In our LO creation process, it is not only the intervention (ID template) which is created and tested, but also the products (IDDs) which are created using the intervention.

7. Implementation details in first research cycle

In the rest of the paper we describe details of implementing Wademan's DBR model to the first research cycle (Phase 1) for our problem of LO creation.

Four stages of Phase 1 of our model

The intervention for our problem is the ID template. The process starts with analysis of the interaction between the ID and the animator, using a generic ID template. In this phase, we identify the problem/s with the generic ID template/s and a product to address this problem/s. We devise an intervention and test the intervention for its usability. (See figure 10)

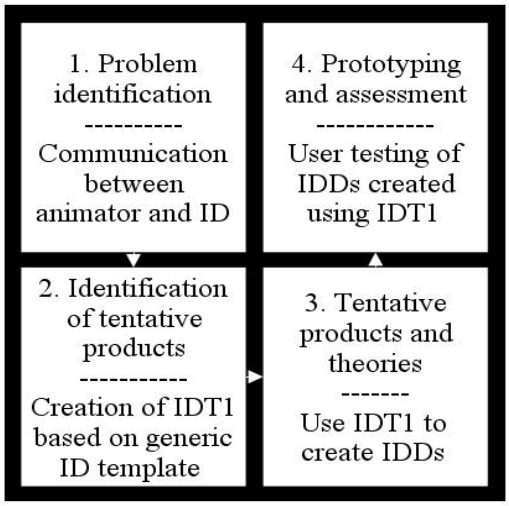

Figure 10: Stages of Phase 1 of our DBR model

7.1. Phase 1: Stage 1: Problem identification

In this stage, the communication between the stakeholders of LO creation process is analyzed (see figure 11). The stakeholders are the animator, ID writer, SME and the researcher. The communication between the ID writer and animators is studied specifically on the basis of the IDDs created using a generic ID template, used by various organizations. The goal of this stage is to specify the gaps in the communication between the ID writer and the animator.

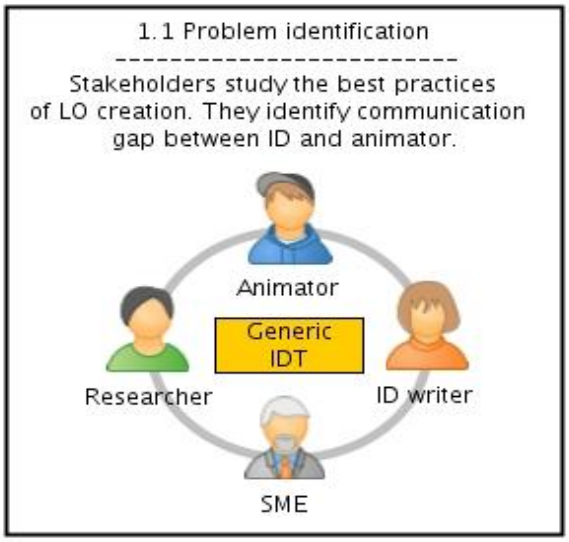

Figure 11: Phase 1 Stage 1: Problem identification

7.2. Phase 1: Stage 2: Identification of tentative products and design principles

An ID template is created (see figure 12) using the generic ID templates (Websites: Excelsoft, Enspire and US patents), which is suitable for the context of our research problem. Prominent examples and principles are also referred during this stage. Additionally, the context in which the intervention is going to be applied is considered. Few adaptations to these templates are done in order to suit the context. The new template is titled as IDT1.

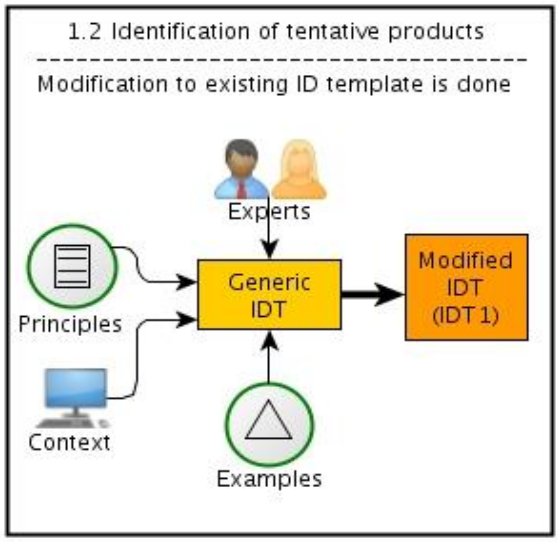

Figure 12: Phase 1 Stage 2: Identification of tentative products

7.3. Phase 1: Stage 3: Applying tentative theories

IDT1 is designed, having five sections for getting relevant information about the concept from the instructional designer. These sections are linear in nature, to facilitate the user to explain the concept. The details of the sections are given below:

1. Information: Basic information about the domain area, course name, definitions of keywords, Aim/Learning objectives: What is the aim of creating this LO, OR what will the users be able to do by using this LO.
2. Concept details: Detailed and stepwise explanation of the animation in the LO.
3. Interactivity and boundary limits: Details of how users can interact with the LO
4. Assessment questions: Multiple Choice questionnaire to test the understanding of the users
5. Further reading: Mainly references section

The structure of IDT1 has prompts added to facilitate the user (instructional designer) to follow them and create the IDD (see figure 13). These prompts are in the form of guiding principles in interaction and graphic design.

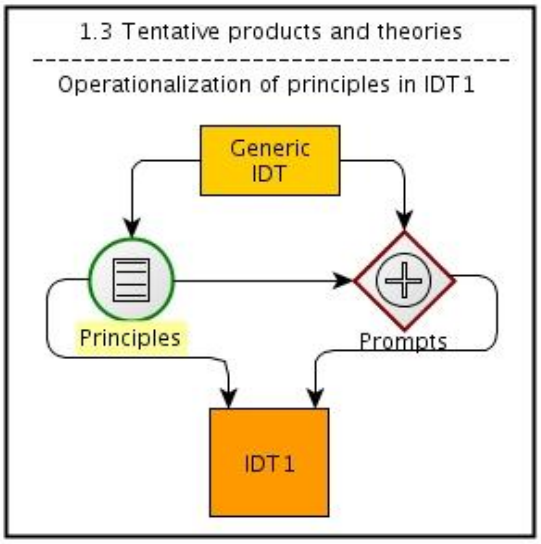

Figure 13: Phase 1 Stage 3: Tentative products and theories

7.4. Phase 1: Stage 4: Prototyping and assessment of preliminary products and theories

In this stage, the IDs use IDT1 to create the IDD documents which are tested for usability (see figure 14). instructional designers are graduates having 1-2 years of experience in ID writing, although none of them posses a formal degree in ID. For this study, 10 IDDs are created. Care is taken to choose IDDs from different subjects deliberately, to get a feedback for various subject domains.

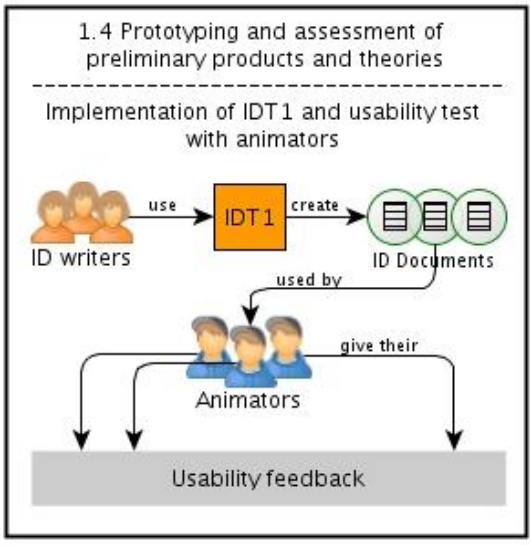

Figure 14: Phase 1 Stage 4: Prototyping and assessment

User testing was done for the animators (who are the users of the IDDs) in order to get the feedback about the IDT1 (which was used to create these IDDs). The details of the user test are:

Process
The softcopy versions of the IDDs selected for the first study were given to the animators. They study each IDD for 30 minutes approximately and later indicated their feedback about the IDD. Apart from indicating their choice on the Likert scale, they wrote the reason for their choice.

Sample
Using convenience sampling, six animators working for an eLearning project were chosen as sample. All the animators have 1-3 years experience of working on LO creation. They have basic education in one or more animation software used in LO creation.

Tool
The tool used for getting the feedback is System Usability Survey (SUS) form (Brooke, 1996). SUS is used widely by researchers for testing usability for various advantages it has over other data collection tools (Bangor, et al, 2009). The respondents are supposed to give a degree of agreement or disagreement for the questions above through a Likert scale having 5 degrees. They range from strongly disagree (1) to strongly agree (5). The scale was used as it is in the original. Additionally, the animators were requested to write a one-line reason for their choice. This was done to get qualitative feedback.

Results
According to the practitioners of SUS, a product is considered usable if the SUS score is greater than 68. The average SUS score of the IDDs created using IDT1, was 36.75 (table 3) which is less than the recommended score of SUS. The results suggest that IDT1 was not usable.

Table 3: User-testing scores (for animators) of IDT 1

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q 10	Total	SUS score
3	3	3	3	1	3	3	3	3	0	25	62.5
1	2	2	1	3	3	2	1	1	3	19	47.5
1	2	1	1	1	1	1	1	1	3	13	32.5
3	1	1	1	2	1	1	1	2	1	14	35
1	1	0	0	0	0	2	0	0	0	4	10
2	2	1	0	2	3	1	2	1	0	14	35
3	3	3	1	2	3	3	3	2	2	25	62.5
2	1	1	0	1	3	0	1	1	1	11	27.5
2	1	0	0	1	1	1	1	1	2	10	25
1	1	1	1	1	2	0	1	1	3	12	30
18	16	12	7	13	18	14	13	12	15	147	367.5
											36.75

The qualitative feedback collected along with the SUS forms is important to understand the lacunae of IDT1 from the point of view of the animators. This feedback is compiled for the next phase.

Discussion

This completes first phase (one research cycle) of the process. For this research cycle, the usability score (for animators) of IDT1 is 38.75. This is below the ideal score suggested in the literature for SUS, which is 68 (Brooke, 1996). It means that the IDT1 is not usable (in its current form) for animators. Preliminary analysis of the qualitative feedback from the animators suggests that modifications done in IDT1 address few problems in their communication with instructional designers.

The feedback about the lack of information related especially for the animation stages is an important outcome of this research cycle. The feedback also sheds light on the absence of instructions and guidelines in the existing ID templates. The future phases (research cycles) will be carried out to resolve the problems reported in the results of this test and refine the intervention (ID template). This will be done by searching for suitable principles from the respective domains, and operationalizing them in the ID templates. In the end, the ID template with sufficient usability score will be used for creating LOs.

8. Summary and future work

We have shown the application of Wademan's DBR model to the first research cycle of the LO creation problem. We have seen that the output of the first research cycle (that is, IDT1) is not a success. However, the process of DBR enables us to use the output and feedback of this phase as a starting point to the subsequent phases, where further iterations can lead to successful outputs (figure 9). The modifications will be done to the intervention based on the analysis of the feedback. The modified intervention will then be tested again, using a similar process. Additionally, more layers of users/experts will be added for testing the intervention. This will help in gathering additional feedback about the usability of the intervention, from multiple stakeholders. Finally, the documentation of the research cycles will be consolidated, to contribute to the existing knowledge of LO creation processes.

Thus applying various phases of design based research is a productive technique to address our research problem of LO creation process having various stakeholders, multiple interacting variables and iterations of the intervention.

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