Fostering Adequate Application of Business Information Visualization with User Assistance Systems and Serious Games

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vorgelegt von

Michael Schelkle
Diplom-Betriebswirt (FH)

Erstgutachter:	Prof. Dr. Marco C. Meier
Zweitgutachter:	Prof. Dr. Axel Tuma
Vorsitzender der mündlichen Prüfung:	Prof. Dr. Jens O. Brunner
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Note: All essays in this dissertation have been slightly modified compared to their published version to facilitate readability. Modifications include a continuous page count, adapted references to other sections, and a central list of references at the end of this dissertation.

List of Essays

This dissertation is based on the three projects “BIV Assistant”, BIV Learning Assistant”, and “Dashboard Tournament”. During the course of these projects, multiple scientific essays have been written that draw either on user assistance systems or on serious games to gain insight on compliance with business information viusualization guidelines or to convey such guidelines (cf. Figure I). In case of essays already published, the corresponding outlet will be shown alongside its current ranking in the “WI-Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik im Verband der Hochschullehrer für Betriebswirtschaft e.V. (WKWI) und des Fachbereichs Wirtschaftsinformatik der Gesellschaft für Informatik (GI-FB WI)” as well as the “VHB-JOURQUAL 3 des Verbands der Hochschullehrer für Betriebswirtschaft e.V. (VHB)”. The research highlights of each essay are presented and the share contributed by the author of this dissertation is mentioned.

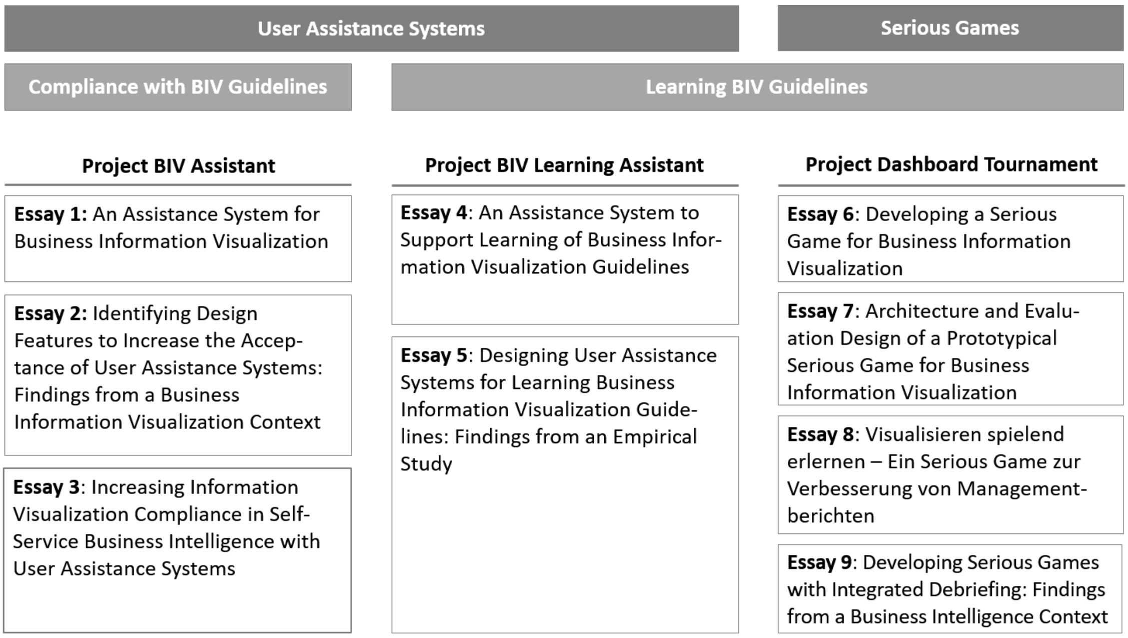

Figure I: Projects and Corresponding Essays of this Dissertation

Essays 1 to 3: Project BIV Assistant – Fostering Compliance with Business Information Visualization Guidelines employing User Assistance Systems

1. Schelkle, Michael (2017): An Assistance System for Business Information Visualization. In: Designing the Digital Transformation. 12th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2017).

Highlights:

- Identification of a research gap: No approach for implemented software, which assists to reveal and amend misleading graphics based on scientific found guidelines, exists so far.
- The concept and design of a novel user assistance system called "BIV Assistant" for applying business information visualization guidelines is described.
- The developed prototype demonstrates that it can amend several instances of inadequately designed business reports.

Ranking (Share: 100%):
WI-Orientierungslisten: Not Ranked
VHB-JOURQUAL 3: Ranked C

2. Schelkle, Michael; Grund, Christian K. (2018): Identifying Design Features to Increase the Acceptance of User Assistance Systems: Findings from a Business Information Visualization Context. 13th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2018).

   Highlights:

   - The software artifact "BIV Assistant" is being evaluated in a laboratory experiment to identify design features that may affect perceived usefulness, perceived ease of use, and intention to use a user assistance system.
   - The results of a summative qualitative content analysis indicate that the most important design features for user assistance systems, which aim at increasing the acceptance of business information visualization guidelines, are error reduction, sufficient explanations, traceability of the actions performed as well as individualization.

   Ranking (Share: 70%):
   WI-Orientierungslisten: Not Ranked
   VHB-JOURQUAL 3: Ranked C

3. Schelkle, Michael; Grund, Christian K.; Aurnhammer, Lena A. E. (2018): Increasing Information Visualization Compliance in Self-Service Business Intelligence with User Assistance Systems. In: European Conference on Information Systems (ECIS) - Proceedings of the Workshop on Designing User Assistance in Interactive Intelligent Systems.

   Highlights:

   - The software artifact "BIV Assistant" is being evaluated in a laboratory experiment to gain insight to what extent user assistance systems affect the intention to comply with business information visualization guidelines in management reporting.
   - The results of a dependent t-test show that the antecedents of the intention to comply with business information visualization guidelines increase when using our artifact. In particular, the increase in report self-efficacy was highly significant and increases in perceived ease of use as well as in perceived usefulness were marginally significant.
   - The results of a multiple linear regression analysis indicate that the propositions from the technology acceptance model hold in a non-technical environment (i.e., compliance of business information visualization guidelines). Perceived ease of complying with business information visualization guidelines, perceived usefulness of complying with business information visualization guidelines, and self-efficacy were able to statistically significant predict the intention to comply with business information visualization guidelines.

   Ranking (Share: 50%):
   WI-Orientierungslisten: Not Ranked
   VHB-JOURQUAL 3: Not Ranked

Essays 4 and 5: Project BIV Learning Assistant - Learning Business Information Visualization Guidelines employing User Assistance Systems

4. Schelkle, Michael; Grund, Christian K.; Preissler, Carina (2018): An Assistance System to Support Learning of Business Information Visualization Guidelines. 13th International Conference on Design Science Research in Information Systems and Technology (DESRIST 2018).

   Highlights:

   - It is unveiled that the development of user assistance systems in the field of business information visualization is not addressed appropriately, in particular with a focus to foster learning business information visualization guidelines.
   - Introduction of the design of a novel user assistance system called "BIV Learning Assistant" for feedback-based learning of BIV guidelines in a work-integrated environment.
   - It is shown how business information visualization guidelines may be conveyed with user assistance systems.

   Ranking (Share: 80%):
   WI-Orientierungslisten: Not Ranked
   VHB-JOURQUAL 3: Ranked C

5. Schelkle, Michael; Grund, Christian K.; Preissler, Carina; Aurnhammer, Lena A. E.; Hurm, Max (2018): Designing User Assistance Systems for Learning Business Information Visualization Guidelines: Findings from an Empirical Study. Under review in: Australasian Journal of Information Systems.

   Highlights:

   - Detailed description of the design and architecture of the user assistance system "BIV learning Assistant"
   - Comparison of different versions of user assistance systems with a printout of BIV guidelines to evaluate differences in knowledge acquisition between these means of assistance.
   - Participants, who used UAS that aim at fostering learning, were significantly better in acquiring BIV knowledge compared to participants provided with other means of learning assistance.
   - User assistance systems that are specifically designed for supporting learning may significantly increase knowledge acquisition.

   Ranking (Share: 75%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked C

Essays 6 to 9: Project Dashboard Tournament - Learning Business Information Visualization Guidelines using Serious Games

6. Grund, Christian K.; Schelkle, Michael (2016): Developing a Serious Game for Business Information Visualization. In: Proceedings of the 22nd Americas Conference on Information Systems (AMCIS).

   Highlights:

   - The development method and concept of a novel serious game for business information visualization is described.
   - It is shown how business information visualization guidelines may be conveyed with different minigames.

   Ranking (Share: 20%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked D

7. Grund, Christian K.; Schelkle, Michael; Hurm, Max (2017): Architecture and Evaluation Design of a Prototypical Serious Game for Business Information Visualization. In: Proceedings of the 13th International Conference on Wirtschaftsinformatik (WI 2017), p. 1271-1274.

   Highlights:

   - Describes how serious games composed of several minigames may be implemented with the game engine Unity.
   - Proposes an experimental design that may be used to measure the effects of serious games, namely intrinsic motivation and learning outcomes.

   Ranking (Share: 15%):
   WI-Orientierungslisten: Ranked A/B
   VHB-JOURQUAL 3: Ranked C

8. Grund, Christian K.; Schelkle, Michael (2017): Visualisieren spielend erlernen – Ein Serious Game zur Verbesserung von Managementberichten. In: Strahringer S., Leyh C. (eds.) Gamification und Serious Games: Grundlagen, Vorgehen und Anwendungen. Edition HMD, Springer, p. 167-181.

   Highlights:

   - Describes the prototype of a serious game for business information visualization for an audience in industry.
   - Design decisions regarding the balancing of play, meaning, and reality are presented.
   - A first evaluation of the prototype shows that motivational outcomes may be achieved and that the learning content is usually recognized.

   Ranking (Share: 20%):
   WI-Orientierungslisten: Ranked B
   VHB-JOURQUAL 3: Ranked D

9. Grund, Christian K.; Schelkle, Michael: Developing Serious Games with Integrated Debriefing: Findings from a Business Intelligence Context. Re-submitted after first review in: Business & Information Systems Engineering.

   Highlights:

   - Compares different versions of a serious game with presentations as a more conventional approach to training.
   - Serious Games do not necessarily lead to increased motivation, but may improve learning outcomes compared to presentations.
   - Integrated debriefing is a novel design principle that leads to higher motivation and learning compared to the often advocated post-hoc debriefing.

   Ranking (Share: 15%):
   WI-Orientierungslisten: Ranked A
   VHB-JOURQUAL 3: Ranked B

1 Introduction

Research on human-computer interaction (HCI) has a long tradition in the domain of Information Systems (IS) (Zhang, 2004). One example of this interaction is business reporting, where so-called business intelligence (BI) software is used by report designers to create business reports for decision-makers (Zhang et al., 2002). Here, the main task is to create transparency and to provide relevant information as a basis for decision making (Weide, 2009) by drawing attention to critical areas and revealing needs for action. Studies show that in order to convey business information, graphical representations are increasingly used in business reporting (Eisl et al., 2015). These graphical representations may be termed Business Information Visualization (BIV), which is the use of computer-supported interactive graphical representations of business data to amplify cognition for improved decision making (Bačić & Fadlalla, 2016). Since the human visual system is by far the richest, most immediate, highest bandwidth pipeline into the human mind (Keahey, 2013), this dissertation focuses on the visualization of graphical elements and their relationships in business reports to show relevant information, which is a key task within BIV (Al-Kassab, Schiuma, Ouertani, & Neely, 2014).

However, despite several guidelines for appropriate BIV already being in existence (e.g. Tufte (1997), Ware (2012), Few (2012), or Hichert and Faisst (2017)), studies show that reports often do not comply with these guidelines (Beattie & Jones, 2002; Beattie & Jones, 2008; Eisl et al., 2015; Eisl, Losbichler, Fischer, & Hofer, 2013). Examples for non-compliant reports include the use of traffic light indicators, which lack details for appropriate decision-making or truncated axes, where the physical representation of a business chart is not proportionate to the underlying numbers (Beattie & Jones, 2008). As a consequence, these poorly visualized reports may guide decision makers to wrong conclusions (Arunachalam, Pei, & Steinbart, 2002; Eisl et al., 2013), which can lead to tremendous negative results. The German project Airport Berlin Brandenburg for example wasted billions of euros (Timmler, 2016), or the Landesbank Sachsen had to be sold to its competitor (Tagesthemen, 27.08.2007 - cited from Mertens (2009)), because the reports that were used failed to support management decisions due to insufficiently designed visualizations.

This dissertation addresses the root causes of this problem, which are twofold. First, users' lack of compliance with BIV guidelines due to unsatisfactory software support (Riedner & Janoschek, 2014). Second, limited knowledge about BIV guidelines and their application due to insufficient training possibilities (Riedner & Janoschek, 2014) as well as insufficient BIV education in school or higher education when studying business administration (Kohlhammer, Proff, & Wiener, 2013).

Since user assistance systems (UAS) help users to perform their tasks better (Maedche, Morana, Schacht, Werth, & Krumeich, 2016), they seem to be a promising approach to improve this situation. Due to their various applications (Ludwig, 2015), UAS may help to foster both, compliance of BIV guidelines as well as training BIV users to learn such guidelines in workplace learning, which is referred to as the acquisition of professional competence and expertise through the engagement in work tasks (Bauer & Gruber, 2007). Hence, this dissertation aims to contribute to gain insight on answering the following research questions (RQ):

RQ 1: To what extent do User Assistance Systems affect the intention to comply with Business Information Visualization guidelines in management reporting?

RQ 2: To what extent can User Assistance Systems support feedback-based learning of Business Information Visualization guidelines?

To accentuate the need for this research, we refer to the grand challenges in the field of IS postulated by Mertens and Barbian (2015). In order to answer RQ 1 we developed a prototypical UAS, the "BIV Assistant", which is able to automatically correct inadequately visualized elements of business reports to comply with given BIV guidelines while using BI software (i.e., decision support systems). This meets the grand challenge of developing "assistant systems to customize the parameters of Decision Support

Systems (DSS)”, which aims at a reliable interpretation and visualization of results (Mertens & Barbian, 2015). Next, to answer RQ 2 we built on the knowledge of the first research project and developed a new UAS, the “BIV Learning Assistant”. This prototype aims at fostering learning BIV guidelines while report designers create business reports (i.e., real-time computer-assisted training). Here, we address a grand challenge concerned with “personalization of instruction and training in business contexts, real-time instruction”, which has the objective to offer “help (in real-time) when an employee runs into difficulties during a task” (Mertens & Barbian, 2015).

Besides UAS, another promising approach that was shown to support learning and motivation in several areas is using games and game elements (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Faria, Hutchinson, Wellington, & Gold, 2009; Grund, 2015; Wouters, van der Spek, & van Oostendorp, 2009). When games have an educational purpose and are not played primarily for amusement, they may be called serious games (SG) (Abt, 1987). While UAS can be used to foster technology-supported learning of BIV guidelines when performing a specific task (i.e., workplace learning), serious games may complement the aspect of learning in a specifically designed learning scenario. As conventional teaching is widely used in the latter scenario, the question arises what constitutes good design for SG to increase motivation and learning outcomes compared to conventional teaching. Therefore, this dissertation also aims to contribute to answering the following RQ:

RQ 3: How should serious games be designed to increase intrinsic motivation and learning outcomes, in particular with regard to learning BIV guidelines?

To find answers to RQ 3, we developed a SG, the “Dashboard Tournament”. We draw on the human-centered design process, which is well-known in the domain of HCI (Earthy, Jones, & Bevan, 2001) and identified concrete design features for SG. These design features shall be considered by SG developers in order to achieve SG that may be superior to traditional teaching.

Since this dissertation draws on newly developed prototypical software artifacts (i.e., BIV Assistant, BIV Learning Assistant, and Dashboard Tournament) to contribute to gaining insight on the outlined challenges, the overall methodological approach may be described as Design Science Research (DSR), which will be explained in section 2 in more detail (Hevner, March, Park, & Ram, 2004; Kuechler & Vaishnavi, 2008; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007).

The remainder of this dissertation is organized as follows: Section 2 features essays addressing UAS and SG that are concerned with the adequate application of BIV guidelines. In section 3, the dissertation closes with a summary of the findings and an outlook on future research possibilities.

2 Essays on Fostering Adequate Application of Business Information Visualization

As already mentioned, this dissertation refers to prototypical artifacts that have been evaluated for scientific findings, which is typical for DSR (Peffers et al., 2007). Hence, in a next step, the DSR paradigm is explained (cf. Figure 1). DSR is concerned with the development of novel and useful artifacts to solve relevant problems (Gregor & Hevner, 2013; Hevner et al., 2004; Peffers et al., 2007). DSR projects typically draw on the IS research framework for DSR introduced by Hevner et al. (2004) and adapted by Hevner (2007) (cf. Figure 1).

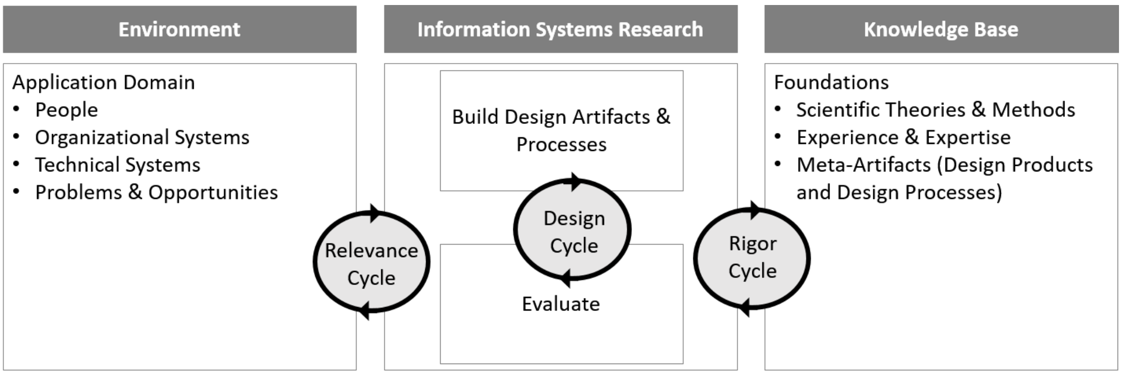

Figure 1: IS Research Framework for DSR (adapted from Hevner et al. (2004) and Hevner (2007))

This framework comprises the aspects environment, knowledge base, and IS research. The environment defines the problem space in which the phenomena of interest are addressed (e.g., people or technical systems) (Hevner et al., 2004). The knowledge base provides foundations and methodologies from which IS research is accomplished (Hevner et al., 2004). The IS research part of the framework addresses research through building and evaluation of artifacts, which are designed to meet identified needs (Hevner et al., 2004). The Relevance Cycle connects the environment of the research project with the DSR activities (Hevner, 2007). The Rigor Cycle links the DSR activities with the knowledge base that informs the research project (Hevner, 2007). The central Design

Cycle iterates between the core activities of building and evaluating artifacts (Hevner, 2007). Figure 2 displays the instantiated key aspects of this dissertation assigned to the IS Research Framework for DSR.

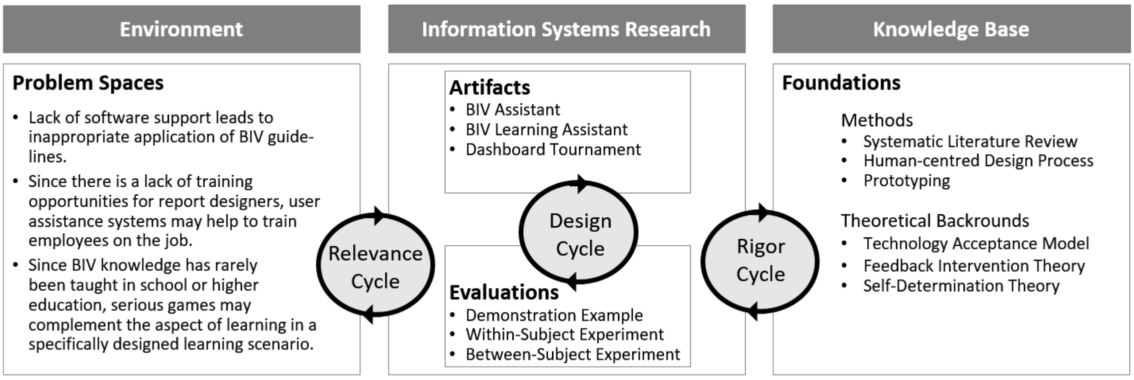

Figure 2: Instantiated IS Research Framework for DSR Referring to this Dissertation's Projects

Again, this dissertation addresses three key issues of BIV. First, a lack of software support results in inappropriate application of BIV guidelines. A systematic literature review indicated that a UAS that supports to overcome this issue does not yet exist. Therefore, a UAS called "BIV Assistant" that aims at complying with BIV guidelines was developed drawing on the human-centred designs process as development approach. The technology acceptance model served as theoretical background to assure the aspects of an easy to use and useful artifact. This artifact proved via demonstration examples that it technically works. A within-subject experiment was conducted to evaluate the "BIV Assistant" on how it affects compliance with BIV guidelines. Second, report designers complain about insufficient training possibilities. To take this issue into account, a further prototype, the "BIV Learning Assistant", was developed referring to feedback intervention theory and evaluated in a between-subject experiment. Last, the "Dashboard Tournament" was developed to show how serious games may affect learning BIV guidelines in a specifically designed learning scenario. For this, we referred to self-determination theory. To evaluate how such a serious game may be designed to foster learning BIV guidelines, a between subject experiment was conducted.

Referring to prior DSR literature, Peffers et al. (2007) introduced a more detailed, synthesized general DSR model, which specifies DSR activities commonly performed in DSR projects (Gregor & Hevner, 2013). These activities are (1) problem identification and motivation, (2) definition of the objectives for a solution, (3) design and development of an artifact, (4) demonstration and evaluation of that artifact, and (5) communication of results (Peffers et al., 2007). Problem identification and motivation means the definition of a specific research problem and justification of the value of a solution. Resources required for this first activity comprise knowledge of the problem's state and the importance of its solution (Peffers et al., 2007). The second activity is the definition of the objectives for a solution. These objectives shall be deduced from the problem definition and knowledge of what is possible and feasible (Peffers et al., 2007). The required resources include knowledge of the state of problems and current solutions, if any, and their efficacy (Peffers et al., 2007). The artifact is designed and developed in the next step. Here, the artifact's desired functionality and architecture are determined and the artifact is created (e.g., constructs, models, methods, or instantiations). For this, knowledge of theory that can be brought to bear in a solution is required (Peffers et al., 2007). The subsequent activity is the demonstration and evaluation of the artifact. This means that the use of the artifact to solve one or more instances of the problem has to be proven. The evaluation measures how well the artifact supports a solution to the problem. This can be done by experiments, simulations, case studies, or other appropriate activities and requires knowledge of relevant metrics and analysis techniques (Peffers et al., 2007). Last, the findings of the evaluation have to be communicated to researchers and other relevant audiences, for example in research publications (Peffers et al., 2007).

We use this framework to assign this dissertation's essays to the introduced DSR activities. The focus or rather the foci of each essay are highlighted with a black frame (cf. Figures 3, 4, and 5). In the following, the essays to answer the introduced RQ are described in more detail. Each essay's essence is presented pertaining to the projects “BIV Assistant”, “BIV Learning Assistant”, and “Dashboard Tournament”.

Essays 1 to 3: Project BIV Assistant - Compliance with Business Information Visualization Guidelines employing User Assistance Systems

The project "BIV Assistant" comprises three essays (cf. Figure 3). Based on these essays, we contribute to answering RQ 1: *"To what extent do User Assistance Systems affect the intention to comply with Business Information Visualization guidelines in management reporting?"*

Project BIV Assistant

DSR Activities	1st Iteration: Essay 1	2nd Iteration: Essay 2	3rd Iteration: Essay 3
(I) Problem identification and motivation	Lack of software support leads to inappropriate application of BIV guide-lines.	Research on UAS has scarcely addressed design features that may increase the intention to use UAS.	Research does barely discuss how UAS affect the intention to comply with BIV guidelines.
(II) Definition of objectives for a solution	Implementation of a proto-typical UAS that may increase the acceptance of appropriate BIV.	Identification of design features that positively affect perceived usefulness, perceived ease of use, and intention to use UAS.	Gain insight to what extent UAS affect the intention to comply with BIV guidelines in management reporting.
(III) Design and development	The artifact "BIV Assistant" is designed referring to the Technology Acceptance Model.	Detailed description of the design of the BIV Assistant referring to a framework of guidance design features.	Use of the BIV Assistant developed in previous design cycle.
(IV) Demonstration / Evaluation	Functional test of the artifact by using demon-stration examples.	Summative qualitative content analysis based on a laboratory experiment.	Dependent t-tests & multiple linear regression analysis based on a laboratory experiment.
(V) Communication	DESRIST 2017	DESRIST 2018	ECIS 2018

Figure 3: Overview of the Project BIV Assistant – Breakdown by DSR Activities

Essay 1 “An Assistance System for Business Information Visualization” (Schelkle, 2017) is the first of three essays that each focus on compliance with BIV guidelines. This research in progress article shows that prior research does not discuss UAS that help to comply with BIV guidelines. To address this research gap, the paper defines the overarching research objective to gain insight on the extent to which UAS affect the acceptance of BIV. Since no appropriate artifact could be identified to answer this question, the essay introduces the design of a UAS called the “BIV Assistant”, referring to the Technology Acceptance Model (Davis, 1986) as theoretical background. In addition, a first prototype of the BIV Assistant was implemented in a SAP UI5 environment. This prototype screens business reports for inadequate BIV (e.g., a truncated axis) and prompts a warning message based on the respective BIV guideline, if an inadequately visualized element is detected. The report creator can then decide whether the BIV Assistant should automatically amend the inadequate BIV by applying the relevant BIV guideline or leave it as is. Moreover, the essay illustrates that the prototype got successfully functionally tested by using demonstration examples, drawing on cases from Courtis (1997). Based on the steps described above, essay 1 is the first iteration of the project “BIV Assistant”, which aims at gaining insight on the intention to comply with BIV guidelines. Providing a successfully tested artifact with regard to its technical functionalities, this first essay lays the foundation for essays 2 and 3, which focus on an evaluation of the overarching research objective.

Essay 2 “Identifying Design Features to Increase the Acceptance of User Assistance Systems: Findings from a Business Information Visualization Context” (Schelkle & Grund, 2018) draws on the first design cycle where the prototypical artifact “BIV Assistant” got introduced.

While the first essay describes the general problem that inadequately designed business reports hinder managers in appropriate decision-making, the key aspect of essay 2 are design features for UAS that help to increase the intention to comply with BIV guidelines. This is motivated by the fact that functionalities in decision support software (e.g., Self-

Service Business Intelligence) are often hard to understand (Maaß, 1993) and that this technology often gears its visualizations towards what is technologically feasible, but not towards what is visually reasonable (Griesfelder, 2014).

A systematic literature review indicates that the area of UAS has scarcely addressed specific design features required for increasing perceived usefulness and perceived ease of using UAS, which may in turn increase the intention to use a system. Hence, the research objective of essay 2 is to identify design features of UAS that positively affect perceived usefulness and perceived ease of use. This second essay describes the design of the prototypical artifact in more detail. For this, we refer to a framework of guidance design features proposed by Morana, Schacht, Scherp, and Maedche (2017), which considers the aspects target, audience, mode, directivity, invocation, timing, intention, content type, format, and trust-building.

To evaluate the effects of perceived usefulness of the UAS and the perceived ease of use of the UAS, we conducted a laboratory experiment. We chose a within-subject design, where participants had to answer open questions on what they liked and disliked about the "BIV Assistant". Moreover, participants were asked to answer multiple questions on perceived usefulness, perceived ease of use, and intention to use the UAS. We conducted a multiple linear regression analysis to see whether perceived usefulness and perceived ease of use affect the intention to use the system. The reason for this is that before finding ways to increase perceived ease of use and perceived usefulness, it should be shown that they might actually increase intention to use the system. Based on our analysis we could confirm that both, perceived usefulness and perceived ease of use are important when designing UAS for BIV. To identify design features of UAS that are important to consider for increasing perceived ease of use and perceived usefulness, we performed a summative qualitative content analysis (cf. Hsieh and Shannon (2005)). Results indicate that perceived error reduction, explanation quality, traceability, and individualization are important design features of UAS.

Summing it up, while essay 1 introduces a prototypical UAS, the second essay provides a more detailed description of the design of the prototype and evaluates this prototype in a laboratory experiment. The experiment reveals design features that help to increase perceived ease of use and perceived usefulness of UAS. Hence, essay 2 contributes to literature by adding the described results to the knowledge foundation of proper UAS design.

Essay 3 "Increasing Information Visualization Compliance in Self-Service Business Intelligence with User Assistance Systems" (Schelkle, Grund, & Aurnhammer, 2018).
Having an implemented artifact (essay 1) and knowing that this artifact is designed in a manner that it may positively affect the intention to use this artifact (essay 2), essay 3 builds on this knowledge and sets out to answer the overarching RQ 1 "*To what extent do User Assistance Systems affect the intention to comply with Business Information Visualization guidelines in management reporting*?" To gain insight on that aspect is important as companies start to establish BIV governance frameworks, which employees are expected to comply with when designing reports. For this, companies often provide employees with guidelines they have to comply with. However, employees may perceive this as additional effort with limited benefit and therefore they may opt to simply not comply. To overcome this, UAS could be used, since they may both reduce the effort to comply as well as describe the usefulness of compliance.

The result of a systematic literature review reveals that although some papers address aspects of acceptance, we could neither identify studies that discuss UAS with a focus on compliance in general, nor how UAS may affect the intention to comply with BIV guidelines.

To answer the aforementioned research question, we conducted a laboratory experiment, since the artifact already has been developed (i.e., ex post evaluation) and since an artificial evaluation environment provides the benefit of controlling for possibly confounding variables as well as allows measuring the efficacy of the artifact (Venable, Pries-Heje, & Baskerville, 2012). Participants were asked to answer questions on their intention to comply with BIV guidelines. For this, questionnaires with validated items from prior research (Venkatesh & Davis, 2000) were translated into German and adapted to BIV guidelines proposed by the International Business Communication Standards (IBCS) Association (Hichert & Faisst, 2017). To analyze if the intention to comply with BIV guidelines as well as its antecedents (i.e., report self-efficacy, perceived ease of use, and perceived usefulness) can be enhanced by using the “BIV Assistant”, we conducted dependent t-tests and compared the means between two measurements. The result shows that the means of all variables increased. In particular, the increase in report self-efficacy was highly significant, and increases in perceived ease of use as well as in perceived usefulness were marginally significant.

To evaluate if the propositions from the Technology Acceptance Model hold in the context of BIV guideline compliance, we conducted a multiple linear regression analysis to compute the influence of the independent variables perceived usefulness, perceived ease of use, and self-efficacy on the dependent variable intention to comply with BIV guidelines. The results indicate that using the BIV Assistant may lead to increased perceived ease of complying with BIV guidelines, perceived usefulness of complying with BIV guidelines, and report-related self-efficacy. Moreover, they show that perceived ease of complying with BIV guidelines appears to be the most important antecedent of the intention to comply with BIV guidelines.

In summary, essay 3 draws on the insights provided by the previous essays and describes the results of a laboratory experiment. The essay contributes to literature by indicating that the BIV Assistant has a positive impact on complying with BIV guidelines. In particular, perceived ease of use of complying with BIV guidelines is especially important to foster the intention to comply with guidelines.

Essays 4 and 5: Project BIV Learning Assistant - Learning Business Information Visualization Guidelines employing User Assistance Systems

Essays 4 and 5 comprise the Project "BIV Learning Assistant" (cf. Figure 4). While the first project covers compliance with BIV guidelines, this project focuses on how UAS may be used to learn BIV guidelines, in particular in a work-integrated environment. Hence, this project sets out to answer RQ 2 *"To what extent can User Assistance Systems support feedback-based learning of Business Information Visualization guidelines?"*

Project BIV Learning Assistant

DSR Activities	1st Iteration: Essay 4	2nd Iteration: Essay 5
(I) Problem identification and motivation	BIV knowledge has rarely been taught in school or higher education. Hence, companies need to train their employees on the job.	Reflection of previous design cycle.
(II) Definition of objectives for a solution	Implementation of a proto-typical UAS that may foster learning BIV guidelines in a work-integrated environment.	Gaining insight to what extent UAS may foster learning BIV guidelines.
(III) Design and development	The artifact "BIV Learning Assistant" is implemented referring to Feedback Intervention Theory.	Elaborated description of the design, functionality, and architecture of the artifact.
(IV) Demonstration / Evaluation	Proposal for a between-subject evaluation design.	Experimental analysis based on a between-subject design.
(V) Communication	DESRIST 2018	Under review in Australasian Journal of Information Systems

Figure 4: Overview of the Project BIV Learning Assistant – Breakdown by DSR Activities

Essay 4 "An Assistance System to Support Learning of Business Information Visualization Guidelines" (Schelkle, Grund, & Preissler, 2018) illustrates that one prominent reason for incorrectly designed visualizations in business reports is a lack of profound knowledge in applying BIV guidelines (Few, 2012; Riedner & Janoschek, 2014). Since this knowledge has barely been taught in school or higher education (Kohlhammer et al., 2013), companies need to train their employees for instance via work-integrated learning (Kohlhammer et al., 2013). Since report designers complain about a lack of training opportunities for BIV (Riedner & Janoschek, 2014), UAS seem to be a promising approach to convey BIV knowledge in a work-integrated environment due to their various fields of application. As feedback is one of the most powerful influences on learning (Hattie & Timperley, 2007), the overarching goal of this research project is outlined: Gaining insight to what extent UAS support feedback-based learning of BIV guidelines in a work-integrated learning environment. In a systematic literature review, we could not identify UAS that provide feedback to foster learning BIV guidelines in prior literature. Hence, the research objective of essay 4 is to introduce such a software-based UAS.

To characterize how feedback relates to learning, we refer to feedback intervention theory (FIT) introduced by Kluger and DeNisi (1996). We use FIT to define the design requirements for our prototypical assistance system. Based on the deduced requirements, a first prototype of the so-called "BIV Learning Assistant" was implemented as a Microsoft Excel Add In. Microsoft Excel was used as it is still widely employed for creating business repots. The "BIV Learning Assistant", screens a business chart in a first step. Next, it shows a comparison of the actual state of this business chart and a target state that complies with given BIV guidelines. Moreover, it provides detailed information on which guidelines are violated and explains why these violations may be misleading for decision-makers. In a next step, the "BIV Learning Assistant" provides short videos that explain stepwise how to amend the business chart to comply with the given BIV guidelines. Last, a history about the progress to comply with BIV guidelines can be shown.

In addition, essay 4 suggests a between-subject experimental design for future research. Since a typical training situation may be that a company provides written learning materials on a specific topic to employees, the control group will be equipped with a written documentation of BIV guidelines. The second group may use the “BIV Learning Assistant”. Hence, we aim to thoroughly evaluate our “BIV Learning Assistant” against using written documents. We expect that using our UAS will positively influence learning BIV guidelines.

In summary, essay 4 draws awareness to the issue of a lack of BIV training possibilities. To bridge this gap, a prototypical artifact, the “BIV Learning Assistant”, is implemented as a proof-of-concept prototype and an evaluation design for ongoing research is proposed. This essay provides the foundation for further research, which will be presented in the next essay.

Essay 5 “Designing User Assistance Systems for Learning Business Information Visualization Guidelines: Findings from an Empirical Study”, builds on the knowledge gained in the previous design cycle. The focus is threefold. First, several UAS that aim at supporting learning are discussed in detail based on a systematic literature review. The core findings demonstrate that there is no consistent opinion on how feedback has to be implemented in UAS to foster learning. In addition, it can be shown that UAS that support feedback-based learning of BIV guidelines in a work-integrated learning environment are not discussed yet in prior literature. Second, essay 5 elaborately describes the design and architecture of the further developed artifact “BIV Learning Assistant”, which is based on specific design principles deduced from FIT. These design principles are: providing corrective feedback, a specific goal, training possibilities, and information about past performance. Third, this artifact got evaluated in a between-subject experiment. A laboratory experiment was chosen, since an artificial evaluation environment has the advantage of controlling for possibly confounding factors and since our artifact has already been developed (Venable et al., 2012). Participants were recruited at a German University and have been randomly assigned to one of three groups. To asses differences in learning outcomes, participants had to do a pre- and posttest in which they had to identify incorrectly visualized elements of five different business charts. After the pretest, all groups had to do several business cases. In each business case, participants had to correct inadequately visualized elements of a business chart. The groups only differed in the means of assistance with which they had to fulfill this task. Group A was treated with the BIV Learning Assistant, group B with a UAS that automatically corrects errors of a business chart, and group C with a printout of BIV guidelines. The results indicate significant differences in learning outcomes between the groups as well as significant differences in knowledge increase with regard to the means of assistance used for learning BIV guidelines.

In summary, while essay 4 introduces a first prototype of the “BIV Learning Assistant” that was able to recognize four inadequately visualized elements, essay 5 describes in detail a further developed artifact. This artifact screens business charts for violations of eight IBCS guidelines, taking column charts, bar charts, pie charts and line charts into account. The design and architecture is elaborately described and the usefulness of the artifact successfully evaluated in a laboratory experiment.

Essays 6 to 9: Project Dashboard Tournament - Learning Business Information Visualization Guidelines using Serious Games

While the first two projects encompass essays that deal with UAS in the field of BIV, essays 6 to 9 introduce a SG that aims to foster learning BIV guidelines among report designers and managers in a specifically designed learning scenario (cf. Figure 5). This SG, called "Dashboard Tournament", is composed of several minigames that confront players with insufficient BIV, which they are supposed to avoid when designing reports. By evaluating the Dashboard Tournament, this project's overarching goal is to find answers to RQ 3: *How should serious games be designed to increase intrinsic motivation and learning outcomes, in particular with regard to learning BIV guidelines?*

Project Dashboard Tournament

DSR Activities	1st Iteration: Essay 6	2nd Iteration: Essay 7	3rd Iteration: Essay 8	4th Iteration: Essay 9
(I) Problem identification and motivation	Inadequate BIV in management reporting due to a lack of knowledge about proper BIV practices.	Even so various SG are discussed in literature, a description of the architecture of a SG for BIV is missing.	Inadequate BIV in management reporting due to a lack of knowledge about proper BIV practices.	SG are scarcely investigated in the field of Information Systems, in particular in the domain of business intelligence & analytics.
(II) Definition of objectives for a solution	Development of a SG that improves players' BIV skills.	Presentation of an architecture for a SG that aims at fostering BIV knowledge.	Raising awareness of SG for conveying knowledge. / Coping with areas of conflict when designing SG.	Comparing our prototypical SG to a more conventional instructional approach and testing two different versions of the game.
(III) Design and development	Human-centred design process is employed to develop our prototypical SG.	The architecture of the SG is deduced from various theories and the artifact implemented using the game engine Unity.	Human-centred design process taking areas of conflict when designing SG into consideration.	Description of the SG.
(IV) Demonstration / Evaluation	A between-subject experimental design is being proposed to evaluate the artifact.	A laboratory experiment using a multivariate 1x3 between-group design is suggested.	Analysis of descriptive statistics & bivariate correlations based on a laboratory experiment.	Analysis of bivariate correlations, MANCOVA, dependent t-tests, & content analysis based on a laboratory experiment.
(V) Communication	AMCIS 2016	WI 2017	Edition HMD	Re-submitted after first review in BISE

Figure 5: Overview of the Project Dashboard Tournament – Breakdown by DSR Activities

Essay 6 "Developing a Serious Game for Business Information Visualization" (Grund & Schelkle, 2016) highlights the necessity for appropriately visualized business reports since poor visualizations might mislead managers in their decision process. The essay shows that a root cause for these inadequate visualizations is a lack of knowledge about proper visualization practices (Few, 2012). Since SG are already used in various domains to improve cognitive learning outcomes (Connolly et al., 2012; Wouters et al., 2009), they also seem to be promising in the field of BIV. To evaluate whether SG may be a superior learning approach compared to more conventional training methods (e.g., lectures), a SG that conveys BIV knowledge is needed. Since we could not identify such games in literature, the objective of essay 6 is to introduce a SG that aims to improve players' BIV knowledge. To improve this knowledge, BIV guidelines may be utilized as a basis. As several guidelines for information visualization exist (e.g., Shneiderman, 1996; Tufte, 1997; Ware, 2012), the essay deduces the IBCS (Hichert & Faisst, 2015) as being especially relevant for the field of BIV. These standards comprise specific guidelines that showcase poor examples of BIV alongside their proposed corrections. Hence, we chose the IBCS to be included in our SG to enable players to identify inadequate BIV and to suggest reasonable improvements.

The essay illustrates that there does not seem to be a development method that is used widely for creating SG, but to be successful, educational objectives as well as providing an entertaining experience are important. This entertaining experience can however only be evaluated when players can play the game during several iterations of development cycles. Therefore, we employed an iterative development approach, the human-centred design process specified by ISO (2010) that is prevalent in the domain of human computer interaction (Earthy et al., 2001). It comprises the steps of planning the whole development, understanding and specifying the context of use, specifying the users' requirements, producing design solutions to meet these requirements, and evaluating the design against its requirements (ISO, 2010). For the latter, the essay proposes a between-subject experimental design to evaluate our project.

In summary, this research in progress essay raises awareness that report designers lack profound BIV knowledge due to insufficient education. To convey such guidelines, SG may be useful and hence, the essay introduces a first prototypical SG, the “Dashboard Tournament”, as well as the method used to develop this SG. With this first iteration, essay 6 lays the foundation of the project “Dashboard Tournament”.

On the basis of the previous article, **Essay 7** “Architecture and Evaluation Design of a Prototypical Serious Game for Business Information Visualization” (Grund, Schelkle, & Hurm, 2017) focuses on the technical architecture of the prototypical SG “Dashboard Tournament”. In a first step, the essay illustrates that even so several SG are discussed in literature, a detailed description of the architecture of SG for BIV is missing. To fill this gap, the essay’s objective is to present an architecture for a SG that aims at improving BIV knowledge. To deduce features on how SG may motivate users, self-determination theory (Deci & Ryan, 1985) is discussed. According to this theory, intrinsic motivation can be fostered by enabling perceived competence, autonomy, and relatedness (Ryan, Rigby, & Przybylski, 2006). Perceived competence may be increased when players succeed in the different minigames and earn points for doing so. Relatedness may be achieved by letting players compete in the same room and using leaderboards that allow comparisons with other players. Last, autonomy may be achieved when players choose their own approaches of how to succeed in the minigames.

With regard to the architecture, the essay describes the different scenes, classes and panels of the game, which is developed with the game engine Unity and C# as the programming language. The scenes describe the screens that players will access during the course of the game. The classes store the data necessary for the scenes to operate and the panels describe the graphical elements inside the scenes. The essay lays out that the “Dashboard Tournament” has a modular structure, where minigames can be added or removed during future development cycles. This detailed technical description of the SG may be used by both, the SG industry as well as researchers when developing SG for management support.

Another core aspect of the essay is the proposed evaluation. To assess potential motivational benefits of the game as well as learning outcomes, the essay suggests a laboratory experiment using a multivariate 1x3 between-group design. The groups will be provided with different treatments, which vary in how they aim to increase motivation and BIV capabilities. It is proposed that the first group will have to play the “Dashboard Tournament” in a multiplayer mode, where the participants compete with each other. The second group will have to play a single player mode, where there is no competition at all. The control group will have to listen to a presentation.

In summary, essay 7 shows a detailed technical architecture of a SG that aims at improving BIV skills. Moreover, compared to essay 6 a detailed proposal for evaluating the effects of different modes of the “Dashboard Tournament” in comparison with a presentation is discussed.

In **essay 8** „Visualisieren spielend erlernen – Ein Serious Game zur Verbesserung von Managementberichten“ (Grund & Schelkle, 2017), results of a first evaluation are discussed focusing on an audience in industry. The essay has two objectives. First, it aims at raising awareness that SG may be beneficial to convey knowledge in the field of management reporting. Second, it aims at facilitating the challenging design process of SG by discussing how to cope with areas of conflict when designing such a game. These areas of conflict comprise the aspects “play”, “meaning”, and “reality”, which have to be balanced during the creation of SG (Harteveld, Guimarães, Mayer, & Bidarra, 2010). The “play” aspect refers to the game experience of players, which means for example having fun and being immersed. Psychological aspects, such as trying to make sure that learning happens successfully is addressed by the “meaning” aspect. The “reality” aspect comprises the subject matter that is covered in SG, and represents the real world (in our case management reporting and report design). Again, these three competing aspects have to be balanced, which leads to so-called design dilemmas and trilemmas. For example, the representation dilemma (Harteveld et al., 2010) illustrates that SG may not be able to make abstractions to support gameplay (i.e., play component) and be very realistic (i.e., reality component) at the same time. Hence, a trade-off has to be found for every SG (Harteveld et al., 2010).

In addition, essay 8 presents the results of a first evaluation conducted with students of a management reporting seminar. The results indicate that the game may foster motivation and that the learning content is mostly recognized among students.

In summary, this essay provides a specific example on how the areas of conflict "play", "meaning", and "reality" may be handled during the process of designing a SG. The first evaluation shows that the Dashboard Tournament may positively affect motivation and learning. However, since it has been conducted in an early development stage, the results may be interpreted as a first indication, which is the reason why further research is provided in the next essay.

Essay 9 "Developing Serious Games with Integrated Debriefing: Findings from a Business Intelligence Context" is the capstone essay of this project. This essay highlights the issue that SG have barely been investigated in the field of IS, in particular in the domain of business intelligence and analytics. Hence, based on the finalized version of the "Dashboard Tournament", it investigates two main aspects. First, essay 9 aims at evaluating the effects on motivation and learning outcomes using a SG for BIV compared to more traditional teaching methods (i.e., presentations). Since one key aspect in the domain of DSR is to generate knowledge about how an artifact is best designed to fulfill its purpose (Hevner et al., 2004), the essay gives insight on how a SG may be designed to foster learning and motivation in the field of BIV. We focus on the design of the so-called "debriefing", which is considered an essential part of any SG, where instructors discuss the learning content of the game after the experience to ensure learning outcomes (Garris, Ahlers, & Driskell, 2002). This design aspect is however often not prominently investigated or even ignored by SG scholars (Crookall, 2010). Moreover, the usual proposal to conduct the debriefing after the game experience might be accompanied with logistical drawbacks, since it requires participants of SG to be spatially and/or temporally synchronized with an instructor or so-called "debriefer" (Lederman, 1992). Hence, the essay’s second aim is to provide insights on motivational effects and learning outcomes of integrated debriefing compared to post-hoc debriefing as a design principle for SG.

To investigate the two outlined aspects, we compared three different groups. Two groups played different versions of the game and one group was attending a presentation about the same learning content, which represented a more conventional training method. Even so, we expected that SG in general will lead to increased motivation compared to presentations, our evaluation showed a rather different picture. The results indicate that SG in general do not necessarily lead to increased motivation compared to presentations. However, our suggestion of integrated debriefing shows clear advantages in terms of motivation and learning compared to a game with debriefing after the experience. The latter was even inferior to a conventional presentation.

In summary, based on the conducted evaluation, we conclude that SG can be helpful to increase BIV capabilities when these SG account for integrated debriefing as a design principle rather than post-hoc debriefing. Hence, essay 9 especially contributes to literature by adding the described design principles to the knowledge foundation of appropriate SG design.

In the following, each essay included in this dissertation will be presented in detail. As mentioned earlier, please note that all essays have been slightly modified compared to their published version to facilitate readability. Modifications include a continuous page count, adapted references to other sections, and a central list of references at the end of this dissertation.

2.1 Essay: An Assistance System for Business Information Visualization

Author:	Michael Schelkle Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg michael.schelkle@wiwi.uni-augsburg.de

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2.1.1 Abstract

Business Information Visualization (BIV) is increasingly recognized in research and practice. Nevertheless, studies show that BIV is often inappropriately applied in business reporting, which may lead decision makers to wrong conclusions. Users who create these reports complain about difficulties to implement appropriate BIV due to insufficient software support. As a result, BIV acceptance suffers. A promising approach to overcome this are user assistance systems (UAS). Hence, the overarching goal of our research project is to gain insight to what extent UAS affect the acceptance of BIV. Since we could not identify in literature a UAS that helps to apply appropriate BIV, we intend to develop such a UAS first. Based on design science research, the aim of this paper is to introduce a UAS prototype that may increase BIV acceptance. Besides evaluating UAS on acceptance, the artifact may help practitioners to adhere to appropriate BIV in their everyday work.

2.1.2 Problem Identification and Motivation

The relevance of appropriate business information visualization (BIV) for decision support is supported by findings in literature (Al-Kassab et al., 2014) and is increasingly recognized by companies to avoid threats and realize opportunities (Riedner & Janoschek, 2014). A recent study shows that 78% of the respondents rate BIV important or very important due to the avoidance of misapprehensions and faster information transfer (Riedner & Janoschek, 2014). On the other hand, research shows that BIV is often not appropriately applied within business reporting (Eisl et al., 2013; Eisl et al., 2015). Such insufficient BIV may lead to selective or distorted perception (Eisl et al., 2013). For example, truncated axes exaggerate the magnitude of a trend, because the sizes of intervals on the vertical axis are unequal (Arunachalam et al., 2002). In consequence, these reports do not fulfil their central tasks: Creating business transparency and providing relevant information as basis for decision making (Weide, 2009) by drawing attention to critical areas and revealing needs for action. It is has been shown that this deficiency may guide decision makers to wrong conclusions (Arunachalam et al., 2002; Eisl et al., 2013), which can lead to tremendous negative results. For instance, the German project Airport Berlin Brandenburg wasted billions of euros (Timmler, 2016) since managers relied on poorly visualized reports (von Bullion & Ott, 2012).

A technology, which is used to create management reports and is gaining importance in the field of Business Intelligence, is Self-Service Business Intelligence (SSBI) (Bange et al., 2017). Here, users have a variety of personal decision support features (e.g. visualizing) to independently develop their own management reports in a timely manner (Poonnawat & Lehmann, 2014). One pitfall however is, that this technology often gears its visualizations towards what is technically feasible, but not towards what is visually reasonable (Griesfelder, 2014). Since SSBI users can be regarded as relative BIV layman, they complain about difficulties to implement appropriate BIV, which leads to a lack of BIV acceptance (Riedner & Janoschek, 2014). One reason for this is insufficient software support that fails to assist in creating reports based on predetermined BIV guidelines

(Riedner & Janoschek, 2014), such as the International Business Communication Standards (IBCS). Since user assistance systems (UAS) help users to perform their tasks better (Maedche et al., 2016), it appears to be a promising approach to increase the perceived usefulness and perceived ease of use of BIV. This leads to enhanced acceptance, referring to the technology acceptance model (Davis, 1986). According to the design science research (DSR) methodology proposed by Peffers et al. (2007), this paper aims to introduce a prototypically implemented software artifact as preliminary result.

The following sections will outline the research objective and the design and development of the prototype. Its demonstration and proposed evaluation is outlined, before the paper closes with a preliminary conclusion and a plan for future research.

2.1.3 Objective of the Research Project

2.1.3.1 Research Objective

The project's overarching goal is to gain insight to what extent UAS affect the acceptance of BIV in management reporting, in particular in an SSBI environment. To evaluate this, UAS that analyze business charts for inadequate BIV and correct shortcomings according to scientific found guidelines have to be investigated. Since after a systematic search we could not identify such UAS in literature, in a first step a UAS for BIV has to be developed. Thus, the research objective of this article is:

Designing a software-based user assistance system that increases the acceptance of appropriate business information visualization.

Herewith we follow the call of Maedche et al. (2016) to study the effects of assistance systems in the field of information systems research and provide a specific solution in the form of a prototype, based on DSR (Hevner et al., 2004).

2.1.3.2 Related Work

Before a UAS for fostering the acceptance of adequate BIV is developed, we want to characterize the state of the art of UAS that help to avoid misleading BIV. Since studies in BIV are fundamentally multidisciplinary, literature from prior research in computer science, human visual perception, and an application domain (i.e., management accounting) (Ware, 2012) was included in our literature search. We conducted the search based on the term "user assistance system" in the databases IEEE Xplore, ACM digital library, AIS Electronic Library, and Emerald Insight to reflect the before mentioned multidisciplinarity. To complement the search, management accounting as well as information systems journals were included (i.e., HMD Praxis der Wirtschaftsinformatik, Decision Support Systems, Management Accounting Research, Journal of Management Accounting Research, Journal of International Financial Management and Accounting, Advances in Management Accounting, Management Accounting Quarterly). Even so UAS could be identified (e.g., UAS for: a ticketing process of an issue tracking system (Haake, Morana, Schacht, Zhou-Hartmann, & Maedche, 2016), remote experimentation (Harkin, Callaghan, McGinnity, & Maguire, 2005), fostering multimedia skills (Di Valentin, Emrich, Werth, & Loos, 2014)), none of the articles characterizes a UAS for BIV.

Since this first search did not reveal a specific UAS, which focuses on BIV guidelines, a further search comprising the terms "chart" and "misleading" and synonyms thereof was conducted. Here several publications (Beattie & Jones, 2002; Harding & Widener, 1988; Raschke & Steinbart, 2008; Woller-Carter, Okan, Cokely, & Garcia-Retamero, 2012) got identified that deal with the topic of misleading BIV and show a demand for user assistance. However, these articles do not describe or develop a concrete software application.

Referring to these reviews, no approach for implemented software that assists to reveal and amend misleading graphics based on scientific found guidelines could be identified. This shows a research gap that we want to bridge with our research project.

2.1.4 Design and Development

2.1.4.1 Theoretical Background

Business Information Visualization

Information visualization can be considered as an aid of thought to assist managers in decision making (Al-Kassab et al., 2014). When information visualization technologies are used to visualize business information (e.g., charts or tables) it is referred to as BIV (Tegarden, 1999). Hence, BIV is the use of computer-supported interactive visual representations of business data to amplify cognition for improved decision making (Bačić & Fadlalla, 2016). This involves defining graphical elements and their relationships to display relevant information (Al-Kassab et al., 2014). Based on the approach of external cognition (i.e. the use of the external world to accomplish cognition), the main idea of BIV is, that visual representations provide information to amplify cognition to support decision making (Card, Mackinlay, & Shneiderman, 1999).

Cognitive theories help to determine how information has to be visually presented to amplify cognition. For example, cognitive load theory refers to the total amount of mental effort being used in the limited working memory and gives guidance on how to design the presentation of information for improved intellectual performance (Sweller, 2011). Cognitive fit theory proposes that the match between task (e.g., detect relationships) and presentation format (e.g., diagram) leads to superior task performance (Vessey, 1991).

One approach to comply with this knowledge are guidelines (Ware, 2012). In the context of BIV, we define a guideline as a general rule, principle, instruction, or piece of advice for the use of computer-supported visual representations of business data to amplify cognition. There are several guidelines for information visualization in general (e.g., Few (2012), Tufte (1997)), which draw on those insights. A framework that refers to these guidelines and highlights the design of business reports and presentations are the IBCS (Hichert & Faisst, 2015). Moreover, the IBCS are increasingly recognized by industry (Proff & Schulz, 2016) and showcase comprehensively inadequate BIV examples alongside their proposed corrections (Grund & Schelkle, 2016), which is the reason why we use these guidelines for our UAS.

Technology Acceptance Model and User Assistance Systems.

The technology acceptance model (TAM) was developed to improve our understanding of user acceptance processes and to provide a theoretical basis for a practical user acceptance testing methodology (Davis, 1986). The TAM posits that perceived usefulness and perceived ease of use determine an individual's intention to use a system (Davis, 1986). Davis (1986) defines perceived usefulness as the extent to which a person believes that using a particular system will enhance job performance. Perceived ease of use is defined as the degree to which a person believes that using a particular system will be free of physical and mental effort (Davis, 1986).

Since UAS are defined as an intelligent and interactive information technology component that enables individuals to perform tasks better (Maedche et al., 2016), it is a promising approach to improve the acceptance of adequate BIV. UAS guide users while performing a specific task (Maedche et al., 2016) (e.g., creating visualizations), which may increase the perceived ease of use. Moreover, further determinants of perceived usefulness, such as job relevance, output quality or result demonstrability (Venkatesh & Bala, 2008) may be positively affected. Job relevance is given as our UAS supports users (e.g., management accountants) in performing their task of creating visualizations for reports. The output quality may increase due to adherence to scientific found BIV guidelines. Since reports are a mean of communication and it can be measured if a visualization adheres to a set of predetermined guidelines, result demonstrability is given.

Since the TAM is a widely employed model of adoption and use and has shown to be highly predictive for these items (Venkatesh & Bala, 2008), we are going to use it as theoretical background to evaluate our UAS on BIV acceptance.

2.1.4.2 Development Method

For the development of the prototype we draw on the human-centered design (HCD) process, that is frequently used in the domain of human computer interaction (Earthy et al., 2001). The four-staged iterative process comprises *specifying the context of use*, *specifying the user requirements*, *producing a design solution*, and *evaluating the artifact* (Earthy et al., 2001).

The *context of use* is in our case SSBI, in which users widely generate and analyze relevant information without the support of reporting specialists (Taschner, 2014). These users are students of a management information system course. They can be regarded as prospective BIV professionals (e.g., information producer) as studies indicate that managers and students behave similarly (Bolton, Ockenfels, & Thonemann, 2012). In their role, they are confronted with management reports by either producing or consuming them or doing both.

The *user requirement* is to fulfill the specifications of predetermined BIV guidelines by using a UAS that helps to identify and correct inadequate BIV. As a result, users may accept to adhere to adequate BIV.

With the subsequent step, *produce a design solution*, a prototype is developed, which follows the vertical prototyping concept since its system features are available in its final functionality, but limited in scope (Floyd, 1984). The final prototype will meet the requirements of the final application, but has not implemented all, but only a sample (e.g., truncated axis or inverted timelines) of the identified BIV guidelines.

The last step of the iterative part of the HCD process is the *evaluation of the artifact*. We use a two-staged approach for the evaluation. First, we demonstrate the functionality of the prototype. In a second step, we will evaluate the artifact on BIV acceptance referring to the TAM.

2.1.4.3 Design of the Software Prototype

Our UAS, the "BIV Assistant", analyzes graphics for inadequate BIV, e.g., a truncated axis that exaggerates the magnitude of a trend and therefore may lead to wrong decision making. In case the visualization shows inadequate BIV elements, the BIV Assistant will prompt a warning message based on the respective IBCS guideline. Being warned, users receive an explanation why the visualization is inappropriate. Hence, users may perceive adequate BIV as being useful for supporting decision making. In a next step, they may decide if the BIV Assistant should automatically amend the inadequate BIV by applying the relevant IBCS guideline. Herewith, the BIV Assistant helps the user to identify and correct inadequate BIV. Hence, it facilitates to adhere to the IBCS, which may result in an increased perceived ease of use and perceived usefulness.

The prototype of the BIV Assistant, is the result of the first iteration of the HCD process as described in the previous section. The current version of the BIV Assistant detects four different misleading visualization patterns, which refer to Courtis (1997). In his work, Courtis (1997) graphically illustrates four misleading charts extracted from annual reports, together with a correct construction of each graph. The BIV Assistant addresses these visualizations and detects their inappropriateness by referring to specific guidelines from the IBCS.

The first is a truncated axis. Here, the BIV Assistant examines, if the starting value of the axis is zero. If not, based on the IBCS guideline CH 1.1, the warning message "Avoid truncated axes: Charts with value axes not starting at zero […] do not correspond to the numerical values upon which the chart is based. Therefore, value axes should generally start at zero" is displayed (see Figure 1). The user has the possibility to let the BIV Assistant automatically emend the inadequate BIV. Doing so, the BIV Assistant sets the starting value of the axis to zero.

The second misleading element, which can be detected by the BIV Assistant is an inverted timeline. Here the BIV Assistant examines if the values of the time axis are in descending order. In this case, the following message appears: "Your chart contains an inadequately visualized time series. In charts, horizontal axes visualize data series over time […] moving from left to right" (Hichert & Faisst, 2015). This refers to the guideline UN 3.3-1 (Hichert & Faisst, 2015). The BIV Assistant sorts the values to an ascending order to amend this chart.

Revealing filtered elements on the ordinate axis is the third deceptive element that prompts a warning, based on the IBCS guideline ST 3.2: "Your chart contains filtered values. If some important arguments […] are left out, the given answer will not be convincing" (Hichert & Faisst, 2015). The correction of the element is done by clearing the filter.

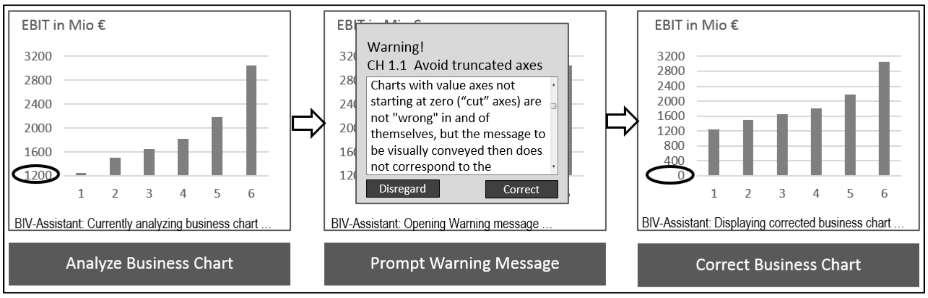

Figure 1: BIV Assistant Prototype – Processing Steps

The last misleading element, which can be detected by the BIV Assistant are differently scaled axes in a combination chart. Referring to the IBCS guidelines CH4/ CH4.1, the following message appears: "Your chart contains differently scaled axes. Proper visual comparison requires the usage of identical scales […]. If presenting more than one chart […] on one page, use the identical scale for these charts" (Hichert & Faisst, 2015). This distorted visualization is rectified by comparing the maximum values of the first and the second ordinate and adjusting the lower value to the higher.

2.1.5 Demonstration and Evaluation

Referring to Peffers et al. (2007), a prototype has to demonstrate to solve one or more instances of the problem. Moreover it has to be evaluated how well the artifact supports a solution to the problem (Peffers et al., 2007). As suggested by Bucher, Riege, and Saat (2008), the prototype got functionally evaluated by using a demonstration example. In our case, drawing on examples from Courtis (1997), the prototype was successfully tested. The prototype demonstrated that it recognizes inadequate BIV, prompts a warning message in which the pitfalls of the diagram are described, and finally corrects the inadequate BIV to meet the respective requirements mentioned by Courtis (1997).

Having finished the development of the prototype, it will be evaluated on BIV acceptance. The effect of the independent variable (i.e., assistance) on the dependent variable (i.e., acceptance of appropriate BIV) will be measured in a between-subject experimental design, where the subjects are randomly assigned into two groups. On a given business case, both groups will have to create or alter management reports using a SSBI tool while adhering to the IBCS. The treatment group may use the BIV Assistant, whereas the control group has to perform the task without any assistance. To evaluate the effect on acceptance, questionnaires with validated items from prior research from Venkatesh and Bala (2008) will be used.

2.1.6 Discussion and Conclusion

BIV suffers from lack of acceptance due to insufficient software support. This unsatisfactory support can be confirmed by our study since no implemented software that assists to identify and correct misleading BIV could be found in literature. Even so, our prototype is a first approach to bridge this gap. At its current stage, it is limited with regard to the number of implemented guidelines. However, additional IBCS guidelines will be implemented during further development iterations. Although the prototype has demonstrated its functionality, the actual evaluation on BIV acceptance still has to be done. Therefore, in a next step the prototype will be evaluated in a between-subject experimental design, referring to validated items from prior research to test the BIV acceptance. Depending on the evaluation results, the overarching project’s scientific contributions may be to underpin or disprove the relative importance of TAM constructs in the area of UAS for BIV. Generalizing our findings, we may contribute to how software-based UAS have to be designed to increase user acceptance. Practitioners who create management reports using SSBI (e.g., managers or management accountants) are addressed, as our artifact may assist in their everyday work.

2.2 Essay: Identifying Design Features to Increase the Acceptance of User Assistance Systems: Findings from a Business Information Visualization Context

Authors:	Michael Schelkle Christian Karl Grund Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg michael.schelkle@wiwi.uni-augsburg.de christian.grund@wiwi.uni-augsburg.de

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2.2.1 Abstract

Business Information Visualization (BIV) is often inappropriately applied in business reporting, which may lead decision makers to wrong conclusions and actions. At the same time, report designers using Self-Service Business Intelligence applications complain about difficulties to implement appropriate BIV due to insufficient software support. To amend this, User Assistance Systems (UAS) might help by reducing the effort to comply with BIV guidelines and by increasing the understanding of their usefulness. Despite these potentially promising benefits of UAS, prior research has scarcely investigated which design features of UAS foster perceived usefulness and perceived ease of use. We thus conducted a laboratory experiment with a prototypical UAS for BIV to identify such design features. Results indicate that perceived error reduction, explanation quality, traceability, and individualization are important design features of UAS. We thus extend prior research by adding these aspects to the knowledge foundation of proper UAS design.

2.2.2 Problem Identification and Research Objective

The way visual information affects human cognition can directly be influenced by the designer of a business chart (Beattie & Jones, 2008). Business Information Visualization (BIV) guidelines give report designers guidance on how to appropriately design business charts and hence assist to avoid misunderstandings (Riedner & Janoschek, 2014). Therefore, BIV is regarded as important by almost 80% of the participants of a recent study (Riedner & Janoschek, 2014). However, research also indicates that BIV is often incorrectly applied within business reporting. For instance, Courtis (1997) shows in his study that close to 50% of 114 examined reports distorted the financial data being presented. Beattie and Jones (1992) found that 30% out of 240 business reports contained graphs with material measurement distortions. Such a distortion may for example be a truncated vertical axis, which overstates the magnitude of a trend (Arunachalam et al., 2002), since the physical representation of such a business chart is not proportionate to the underlying numbers (Beattie & Jones, 2008). Business reports applying inappropriate BIV may give a wrong impression due to a distorted perception (Arunachalam et al., 2002). Hence, these reports do not achieve their essential goal: Create business transparency, draw attention to critical areas and reveal needs for action (Schelkle, 2017). In consequence, decision makers may conclude inappropriately, since they rely on poorly visualized business reports (Arunachalam et al., 2002; Beattie & Jones, 2008).

To design such reports, Self-Service Business Intelligence (SSBI) is increasingly utilized (Bange et al., 2017), where employees may use decision support features (e.g., visualizations) to independently develop their own business reports in a timely manner (Poonnawat & Lehmann, 2014). It is problematic however, that features in SSBI are often hard to understand (Maaß, 1993) and that this technology often gears its visualizations towards what is technically feasible, but not towards what is visually reasonable (Griesfelder, 2014). Hence, more and more user skills are required to assure an adequate application, while the human cognitive capacity remained mainly unchanged over the last 200 years (Denger, Stocker, & Schmeja, 2012). As a result, SSBI users complain about difficulties to adhere to appropriate BIV (Riedner & Janoschek, 2014). In addition, some users do not comprehend the benefits of complying with BIV guidelines due to a lack of explanation (Few, 2012). As a result, these two issues lead to a lack of acceptance to comply with BIV guidelines (Riedner & Janoschek, 2014). This is rooted for instance in unsatisfactory software support that fails to assist in creating appropriately designed reports (Riedner & Janoschek, 2014).

Due to their various applications (Ludwig, 2015), user assistance systems (UAS) seem to be promising to improve this situation as they help users to perform their tasks better by both making them easier to perform and also by showing users the benefits of their suggestions (Maedche et al., 2016). In previous research, we hence introduced a design science research (DSR) project, which aims to develop a UAS that supports employees in complying with BIV guidelines as its overarching goal (the “BIV Assistant”) (Schelkle, 2017). In this first design cycle, we focused on describing the development of a first version of the prototypical artifact. This current study takes on the ideas of the first design cycle and presents the design features of the artifact with the aim of introducing a system that makes it easy to comply with BIV guidelines and that increases perceived usefulness by explaining the benefits of this compliance. This in turn is supposed to lead to a high intention to use the UAS according to the Technology Acceptance Model (Davis, 1986). However, previous research in the area of UAS has scarcely addressed the specific design features required for increasing perceived usefulness and perceived ease of use with UAS (see section 2.2.3). Hence, with this study, we set out to contribute to answering the following research question:

RQ: Which design features of user assistance systems affect perceived usefulness and perceived ease of use?

To investigate this question, we conducted a laboratory experiment, where participants used our UAS. With a questionnaire asking for a qualitative evaluation of our artifact, we identified several important aspects of UAS regarding perceived usefulness and perceived ease of use. Herewith, we follow the call of Maedche et al. (2016) to study the effects of assistance systems in the information systems (IS) domain.

This paper's outline draws on the DSR activities proposed by Peffers et al. (2007), starting with the problem identification and description of the research objective, continued by related work, theoretical background, and the design of our prototypically implemented UAS. The evaluation of the prototype is followed by a discussion, conclusion and outlook on future research possibilities.

2.2.3 Related Work

To see whether prior research in UAS reflects the aspects of perceived usefulness, perceived ease of use as well as the intention to use a system (e.g., UAS for BIV), knowledge and solutions presented in prior literature have to be discussed (Peffers et al., 2007). Hence, we conducted a literature review referring to Webster and Watson (2002) and the taxonomy of Cooper (1988), comprising the characteristics focus, goal, perspective, coverage, and organization (see Table 1).

Table 1: Taxonomy of Literature Reviews Proposed by Cooper (1988)

Focus	Research Outcomes	Research Methods	Theories	Applications
Goal	Integration	Criticism	Central Issues	
Perspective	Neutral Representation	Espousal of Position		
Coverage	Exhaustive	Exhaustive & Selective	Representative	Central/Pivotal
Organization	Historical	Conceptual	Methodological	

We *focus* on the identification of research outcomes and applications (i.e., UAS) with the *goal* to identify central issues concerning the intention to use UAS and its antecedents. We adopt a *neutral position* for representing our findings in order to gain an objective overview of effects that impact the intention to use UAS. Since we describe initial efforts that have provided direction for the field of UAS with regard to design features for the intention to use UAS, perceived ease of use, and perceived usefulness, we follow a *pivotal approach.* The review is *organized* to identify concepts that affect the intention to use UAS.

As studies in BIV are fundamentally multidisciplinary (Ware, 2012), we included literature from prior research in computer science and human visual perception (IEEE Xplore and ACM digital library) as well as business and management (Emerald Insight) in our review. To reflect the AIS Senior Scholars' Basket of Journals and important conference proceedings in the IS field, we added the AIS Electronic Library (AISeL). To complement the search, we included specific management accounting and IS journals (i.e., Decision Support Systems, Management Accounting Research, Journal of Management Accounting Research, Journal of International Financial Management and Accounting, Advances in Management Accounting, HMD Praxis der Wirtschafts-informatik, Management Accounting Quarterly).

The search in the above outlets was conducted without any time restrictions using the search term "*user assistance system*". In total, 16 articles (AISeL (7), ACM (6), IEEE Xplore (3), other outlets (0)) that either describe an implemented UAS, describe the design of UAS, or conceptualize UAS in the field of IS could be identified. Due to length limitations, we are not able to list all 16 references, but these can be provided upon request. Since one article did not qualify for the domain of user assistance systems (Ziegler, Matusik, Pfister, & McMillan, 2003), it was neglected in further analysis. For the remaining 15 articles, we focused on papers with a detailed description of at least one of the following: intention to use, perceived usefulness, or perceived ease of use. Finally, 4 articles met the criteria and qualified for further analysis (cf. Table 2).

Table 2: Concept Matrix of Relevant Papers Identified in the Literature Review

Author	UAS	ITU	PEOU	PU
Haake et al. (2016)	User participation and involvement assistant	X	X	X
Bleser, Hendeby, and Miezal (2011)	Assistance system for industrial assembly tasks		X	
Kehoe, Neff, Pitt, and Russell (2007)	Speech-enabled assistance system for the application Microsoft Paint			X
Kehoe and Pitt (2007)	Speech-enabled assistance system for the application Microsoft Paint			X

ITU = intention to use , PEOU = perceived ease of use, PU = perceived usefulness

Haake et al. (2016) describe a user participation and involvement assistant that enables end users to articulate their requirements and feedback for their currently used IS (i.e., an IT issue tracking system). This UAS is designed to assist end user involvement in continued IS development. In their paper, Haake et al. (2016) discuss that researchers identified user participation and involvement as a factor that can positively influence the perceived usefulness and ease of software use. Moreover, they state that besides perceived usefulness and perceived ease of use the actual performance in use impacts users' satisfaction and is hence an important indicator for the intention to use. They further describe meta-requirements for the design of their UAS. For example, "the current context of the users from a system perspective should be captured" or "users should be assisted with computer-based support to express their requirements" (Haake et al., 2016). These meta-requirements are however not distinctively linked to either one of the concepts intention to use, perceived ease of use, or perceived usefulness.

Bleser et al. (2011) introduce an assistance system which can be used for industrial assembly tasks. They describe that the used technological components of the assistance system (e.g., augmented reality applications and body sensors) facilitate capturing upper-body motions to guide users through an industrial task and hence ease it.

Kehoe et al. (2007) as well as Kehoe and Pitt (2007) describe a speech-enabled assistance system to control simple tasks (e.g., change background colors) in the application Microsoft Paint. The authors point out that the Microsoft Speech Application Programming Interface (SAPI) can be particularly useful in building interactive speech-enabled auditory assistance systems. Using the SAPI application enables the assistance system to be aware of the current position of the auditory assistance output stream, and hence support the navigation of auditory topics.

Referring to the articles described above, we summarize that only 4 (25%) of the identified articles in the field of UAS directly address aspects of the intention to use a UAS, perceived ease of use, or perceived usefulness. The majority of papers address technical components that affect either the perceived usefulness or perceived ease of use of UAS. Only one article briefly addresses all aspects and introduces meta-requirements that have to be reflected for an assistance system that aims to assist in end user involvement in continued IS development (Haake et al., 2016). These meta-requirements are however not specifically linked to the concepts intention to use, perceived ease of use, or perceived usefulness.

As a result, referring to our conducted review, we could not identify prior research that specifically discusses one or more aspects of the intention to use a system, perceived usefulness, or perceived ease of use with regard to UAS that help to comply with BIV guidelines. Although there might be relevant publications in other outlets, we suppose that our literature review has a satisfying degree of comprehensiveness, since researchers argue that a search can be terminated when the authors are confident of the novelty of the identified area (Boell & Cecez-Kecmanovic, 2010). Hence, we claim that our search shows a research gap that we intend to bridge with our study.

2.2.4 Definitions and Theoretical Background

According to Maedche et al. (2016), UAS may be defined as an interactive information technology component that enables individuals to perform tasks better. They do not enforce user’s specific behavior, but guide them while performing a specific task (Maedche et al., 2016).

When information visualization technologies are used to provide graphical representations of business data (e.g., business charts) to amplify cognition for improved decision making, it is referred to as BIV (Bačić & Fadlalla, 2016). This involves defining graphical elements and their relationships to display relevant information (Al-Kassab et al., 2014). This is the focus of our study as the human visual system is by far the richest, most immediate, highest bandwidth pipeline into the human mind (Keahey, 2013).

To give guidance on how BIV is applied appropriately, BIV guidelines may be used (Ware, 2012). They are defined as general rules, principles, instructions, or pieces of advice for the use of computer-supported visual representations of business data to amplify cognition (Schelkle, 2017). In literature, several such guidelines exist (e.g., Few (2012), Tufte (1997)), which refer to cognitive psychology (e.g., cognitive load theory or cognitive fit theory) and profound knowledge of human information processing (Beattie & Jones, 2008). A framework that draws on these guidelines and highlights the design of business reports and presentations is called International Business Communication Standards (IBCS) (Hichert & Faisst, 2015). In addition, the IBCS are increasingly recognized in industry (Proff & Schulz, 2016), showcase comprehensively inadequate BIV examples alongside their proposed corrections (Grund & Schelkle, 2016), and are freely available over the website of the IBCS Association. This is why our UAS employs the IBCS.

To gain insight on the effect of perceived ease of use and perceived usefulness on the intention to use UAS in the field of BIV, we draw on the Technology Acceptance Model (TAM) as theoretical underpinning. It was developed to improve the understanding of user acceptance and to provide a theoretical basis for a practical user acceptance testing methodology (Davis, 1986). The TAM theorizes that perceived usefulness and perceived ease of use determine an individual's intention to use a system (Davis, 1986). Perceived usefulness is defined as the extent to which a person believes that using a particular system will enhance job performance (Davis, 1986). The degree to which a person believes that using a particular system will be free of physical and mental effort is defined as perceived ease of use (Davis, 1986). Thus, when perceived ease of use (i.e., little effort to comply with BIV guidelines) and perceived usefulness (i.e., benefits from complying with BIV guidelines) are high, individuals have a high intention to use a system. Such a system may be a UAS, which guides users (e.g., management accountants) while performing a specific task (e.g., designing business charts) (Maedche et al., 2016). Hence, the provided assistance (e.g., automatically amend a business chart to comply with BIV guidelines) may be perceived to ease the use of this task. In addition, perceived usefulness may be affected by providing guidance on how to appropriately apply BIV and provide explanations why it is beneficial to apply adequate BIV. Hence, we conclude that perceived ease of use and perceived usefulness of UAS are important to foster the intention to use these systems.

2.2.5 Design and Functionality of the Artifact

2.2.5.1 Design of the Artifact

Having guiding functionalities, the BIV Assistant fulfills the requirements of a guidance system, since it integrates expertise of experts (Morana et al., 2017) on appropriate BIV usage. This expertise is reflected by using the guidelines of the IBCS association. Moreover, it provides a recommended solution to a problem (Morana et al., 2017) when the BIV Assistant corrects an inadequately designed business chart. The promised effects of the usage of guidance design features (e.g., decreased cognitive effort) confirm to the constructs of the TAM. Therefore, we draw on the integrated taxonomy of guidance design features proposed by Morana et al. (2017) to assure a comprehensive design of the BIV Assistant. As depicted in Table 3, the characteristics highlighted in grey determine the BIV Assistant's design.

For the detailed description of the design, we refer to Schelkle, Grund, and Aurnhammer (2018). However, we suppose that a brief explanation of the design is required for a better understanding of this study and thus adopt parts of the explanation originally presented in Schelkle, Grund, and Aurnhammer (2018).

Table 3: Guidance Design Features of the BIV Assistant (adapted from Morana et al. (2017))

<table>
<tr><td>Target</td><td colspan="3">Choosing</td><td colspan="3">Using</td></tr>
<tr><td>Audience</td><td colspan="3">Novice</td><td colspan="3">Expert</td></tr>
<tr><td>Mode</td><td colspan="2">Predefined</td><td colspan="2">Dynamic</td><td colspan="2">Participative</td></tr>
<tr><td>Directivity</td><td colspan="2">Suggestive</td><td colspan="2">Quasi-Suggestive</td><td colspan="2">Informative</td></tr>
<tr><td>Invocation</td><td colspan="2">Automatic</td><td colspan="2">User-invoked</td><td colspan="2">Intelligent</td></tr>
<tr><td>Timing</td><td colspan="2">Concurrent</td><td colspan="2">Prospective</td><td colspan="2">Retrospective</td></tr>
<tr><td>Intention</td><td>Clarification</td><td colspan="2">Knowledge</td><td colspan="2">Learning</td><td>Recommending</td></tr>
<tr><td>Content Type</td><td>Trace</td><td colspan="2">Justification</td><td colspan="2">Control</td><td>Terminological</td></tr>
<tr><td>Format</td><td>Text-based</td><td colspan="2">Image</td><td colspan="2">Animation</td><td>Audio</td></tr>
<tr><td>Trust-Building</td><td colspan="3">Proactive</td><td colspan="3">Passive</td></tr>
</table>

The *target* of the BIV Assistant is to facilitate complying with BIV guidelines. This relates to the using aspect, as the UAS engages in a given activity (Morana et al., 2017), which may increase the perceived ease of use, in particular for BIV novices. The *mode* of assistance is predefined as we use BIV guidelines that are determined by the IBCS Association. Since the task to comply with these guidelines can be complex, the BIV Assistant *directs* the user to adhere to the IBCS, which may result in a perceived ease of use of complying with BIV guidelines. UAS should reduce the effort for a users' mental working memory rather than additionally burden it with interruptions at the wrong time (Gregor & Benbasat, 1999). Hence, we decided to use a user-triggered *invocation* and retrospective *timing.* Since the BIV Assistant does not constantly interrupt the multi-staged BIV process (Ware, 2012), the users remain in their thought process and get assistance upon request, which may affect the perceived ease of use.

To increase the perceived usefulness of complying with BIV guidelines, the BIV Assistant shows warning messages and hence informs which elements of the business chart infringe adequate BIV (e.g., truncated axes (Hichert & Faisst, 2015)). The *intention* of the warning pursues two aims. First, it clarifies why a specific inadequately visualized element is misleading. Second, it provides explanations and expert knowledge (i.e., terminological *content*), referring to the expertise from the IBCS. The presentation *format* of these warnings is a combination of text and image. Trust in assistance (e.g., guidance on why and how to comply with BIV guidelines) can have a strong effect on users' intention to follow suggestions (Morana et al., 2017). Hence, we intend to proactively *build trust* and thus positively affect the perceived usefulness.

In summary, the design aspects which may lead to an increased perceived ease of use and perceived usefulness of our UAS, may help to increase the intention to use the BIV Assistant.

2.2.5.2 Functionality of the Artifact

The functionality of our UAS called "BIV Assistant" is divided into three steps. First, it screens business charts for inadequate BIV. This can for example be a truncated axis that exaggerates the magnitude of a trend, which may lead to wrong decision-making. Second, a warning is prompted to the user that makes the user aware of an inadequately designed business chart (cf. Figure 1). If the user requests further assistance, the BIV Assistant opens a pop up window in which an explanation of the visual deficiency is given. This explanation refers to a relevant BIV guideline of the IBCS. In consequence, users may perceive adequate BIV as being useful for supporting decision-making, thus fostering perceived usefulness of complying with BIV guidelines. Last, the user can decide whether the BIV Assistant should automatically correct the inadequate business chart according to the presented guideline or leave the business chart as is (cf. Figure 2). This automated correction may increase the ease of use and hence positively affect the intention to use the system, according to the TAM (Davis, 1986).

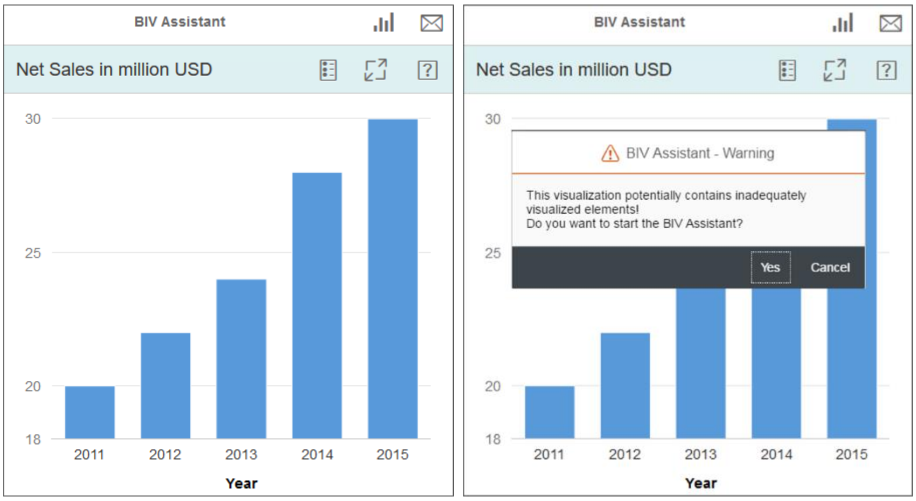

Figure 1: Screenshot of the BIV Assistant – Initial State and Warning Message

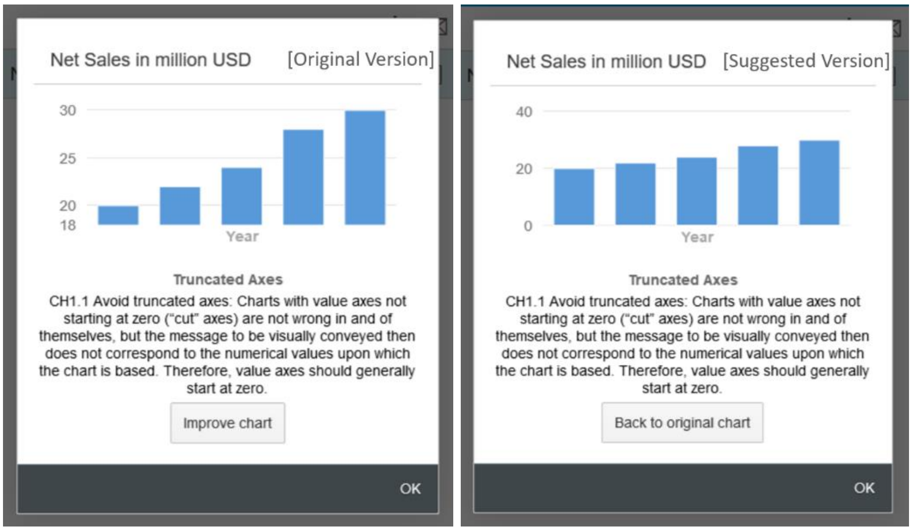

Figure 2: Screenshot of the BIV Assistant – Guideline and Possibility for Automated Correction

2.2.6 Experimental Evaluation

2.2.6.1 Evaluation Design, Participants and Procedure

The artifact's performance should be evaluated against its research objectives (Peffers et al., 2007). To determine the evaluation method, we refer to Venable et al. (2012). We chose a laboratory experiment, since the artifact already has been developed (i.e., ex post evaluation) and since an artificial evaluation environment provides the benefit of controlling for possibly confounding variables. We followed a within-subject design with 14 university students (4 female, 10 male, average age: 22) of an IS course, since studies indicate that managers and students behave similarly (Bolton et al., 2012). Although within-subject designs are susceptible to possible learning effects (Charness, Gneezy, & Kuhn, 2012), we decided to follow such a design, since potential learning effects may be neglected for evaluating the effects of perceived usefulness of the UAS and the perceived ease of use of the UAS. Further, the qualitative assessment of design features is unlikely to be affected by possible learning effects. We further decided to conduct a within-subject experiment as it requires less participants compared to between-subject designs (Lazar, Feng, & Hochheiser, 2010).

To analyze the effects of perceived usefulness and perceived ease of use with regard to the intention to use UAS we differentiate 2 measurement settings. In both settings, participants had to identify misleading elements according to the IBCS guidelines in 4 different business charts, which were presented to the attendees on a questionnaire. The settings of the measurements differ in the type of assistance, however. Since BIV guidelines are typically provided in written documents (e.g., Few (2012), Hichert and Faisst (2015), Ware (2012)), the only assistance allowed in the first setting are the IBCS guidelines, which are published via the website of the IBCS Association. In the second setting, participants could use our BIV Assistant to fulfill the requested task. This way, participants were able to compare our system with the status quo in most companies.

The experiment was structured in multiple stages. First, participants were introduced to the experiment and got a short training on how to access the BIV guidelines of the IBCS Association. In the next step, they had to accomplish the described task according to the first setting. To reduce potential learning effects for the second measurement, participants watched a short movie about information visualization and were asked to note research possibilities in the field of information visualization. The content of the movie was not related to BIV guidelines or UAS. Moreover, we slightly modified the misleading business charts and changed the sequential order for the second setting. Here, participants had to fulfill the described task with the opportunity to use our BIV Assistant. Having completed the task, participants were asked to answer multiple questions on perceived usefulness (e.g., "I find the assistance system to be useful in my job."), perceived ease of use (e.g., "I find the system to be easy to use."), and intention to use the UAS (e.g., "Assuming I have access to the assistance system, I intend to use it."). We referred to items from Venkatesh and Bala (2008), which were measured on a 7-point scale, where 1 = strongly disagree and 7 = strongly agree. In addition, open questions with regard to the design features of the UAS complemented the questionnaire.

2.2.6.2 Evaluation Results

To evaluate the perceived usefulness (PU), perceived ease of use (PEOU), as well as the intention to use (ITU) of our proposed artifact, we performed two analyses. First, we conducted a multiple linear regression analysis to see whether PU and PEOU affect ITU. The reason for this analysis is that before finding ways to increase PU and PEOU, it should be shown that they might actually increase ITU. Second, we performed a summative qualitative content analysis (cf. Hsieh and Shannon (2005)) to identify design aspects of UAS that are important to consider for increasing PU and PEOU.

Items used to measure PEOU, PU, and ITU have been derived from prior research (Venkatesh & Bala, 2008) and showed overall good measurement characteristics (with Cronbach's α ranging from .89 to .93). As a result of our multiple linear regression analysis, the R^2 for the overall model was .79 (adjusted R^2=.75) which is indicative of a high goodness-of-fit (Cohen, 1988). Both PEOU and PU statistically significant predict ITU, with $F(2,13)=20.1$, $p<.001$. When it comes to the individual regression coefficients of PEOU and PU, there are only moderate differences. PEOU significantly predicts PU (β=.48, $p<.05$), which is also the case for PU (β=.56, $p<.01$). These results indicate that PU might have a stronger impact on ITU than PEOU. These outcomes are depicted in Figure 3.

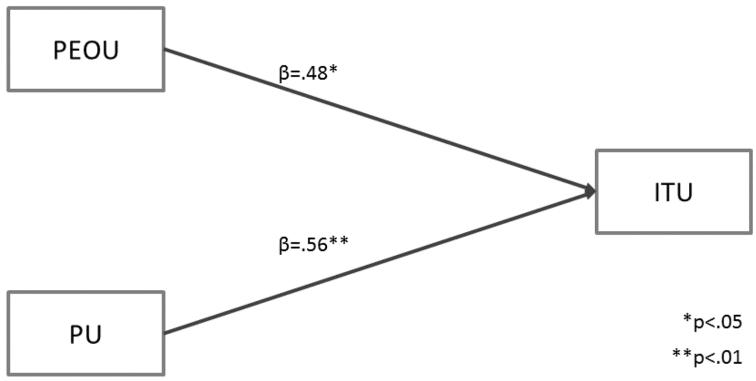

Figure 3: Regression Analysis of Antecedents of ITU

As a result of this analysis, we confirmed that PEOU and PU are both important when designing UAS for BIV. In a next step, we conducted a summative qualitative content analysis (Hsieh & Shannon, 2005) to identify crucial design features that foster PU and PEOU in the context of UAS for BIV. For this, we analyzed participants' responses about their experience. We investigated two different open questions: First, what did participants like about their experience with the BIV assistant? Second, what are potential improvements for the BIV assistant? The answers to these two questions were manually assigned to either PEOU or PU by the authors in a consensual procedure. Table 4 shows the results of this analysis for PEOU and Table 5 for PU.

Table 4: Results of the Summative Qualitative Content Analysis for PEOU

Perceived Ease of Use			
Positive	**#**	**Improvement**	**#**
Easy to Use	3	German Version	2
Good Explanations	2	Change Font Size	1
Fast Correction	1	More Visual Support	1
Good Visuals	1	Less Confirmations	1
		Menu is Strange	1

Table 1. Results of the Summative Qualitative Content Analysis for PU

Perceived Usefulness			
Positive	**#**	**Improvement**	**#**
General Utility	4	More Explanations	3
Error Reduction	3	Show Changes	2
		Ability to Save Results	1
		Customizability	1
		Upload Custom Charts	1
		More Diagram Types	1
		Find Mistakes Simultaneously	1

As can be seen in both Table 4 and Table 5, there are several things participants liked about their experience with the BIV assistant but they also suggested improvements.

When it comes to PEOU, participants highlighted the importance of a general feeling that the artifact is overall easy to use (e.g., "The system is ease and intuitive to use"). Of course, this description does not help in terms of identifying particular design features, however, it underlines the importance of this aspect. Another aspect that was mentioned more than once are good explanations (e.g., "I like the explanations, which are easy to understand"). Here, participants complimented the BIV assistant for its easy to understand explanations. Two additional design features that were mentioned as helpful are the fast correction of mistakes in the charts (i.e., speed), and the quality of the visuals implemented. On the improvement side, participants wished for a German version of the prototype (e.g., “I would welcome a German version.”), which is of course a regional aspect and not a design feature of the BIV assistant. However, it might hint at multilingual features that are welcomed by users of UAS. There are also some scattered suggestions regarding the font size used, the lack of visual support, the note that confirmations were too annoying and that the user interface is somewhat strange.

For PU, participants mentioned that the general utility is most helpful (e.g., “The system does everything that is important to me.”). This is similar to PEOU, where the ease of use was mentioned as something important. Thus, we may conclude that PU is also an important aspect to consider when designing UAS, which is in line with our multiple linear regression analysis. Very close to the general utility of the artifact, participants also mentioned the reduction of errors as an important design feature that they evaluated as helpful (e.g., “The system helps to reduce errors in a timely manner.”). This is, of course, the main functionality of the BIV assistant. However, this might also be important for other UAS as well, since assistance systems usually aim for error reduction (Maedche et al., 2016). Regarding the aspects users wished for, providing more explanations was mentioned most often (e.g., “It is not sufficiently explained what the user has to do.”). This is in line with observations from PEOU, where easy to understand messages were considered a helpful aspect. Thus, we may conclude that the existence but also the quality of explanations is an important design feature in UAS when it comes to both PEOU and PU. Another design feature that was wished for more than once was a transparent depiction of changes that the UAS made (e.g., “The system should show the changes for the improved business chart in an intermediate step.”). This is in line with general usability recommendations, where users should be aware of the system status (Nielsen, 1994). This also shows, however, that users are not only interested in simply improving their charts, but they also want to know what their potential mistakes have been. This design feature might thus also foster learning outcomes when using UAS. As with PEOU, there are several scattered suggestions as to how the BIV Assistant might be improved. They range from saving capabilities to solving several errors at the same time. In the following section, we will discuss these and other findings of our study.

2.2.7 Discussion and Conclusion

Following the DSR activities proposed by Peffers et al. (2007), this study set out to identify design features of UAS that might increase PEOU and PU in order to raise the intention to use UAS. This is important in our context, as our BIV Assistant is supposed to improve BIV in SSBI, but might apply to UAS from other application domains as well. According to Hevner et al. (2004) we hence contribute to design science research as we provide evaluated constructs (i.e., design features for UAS) of an instantiated UAS that may improve existing foundations in the design-science knowledge base of UAS.

Even so, the experiment was conducted with a limited number of participants, our findings revealed some design features of UAS that have not been discussed prominently in prior research. Regarding PU, the most important design features mentioned are the error reduction provided by the UAS, sufficient explanations as well as transparency of changes regarding the charts depicted (i.e., traceability of the actions performed by the UAS). From a PEOU perspective, participants valued explanations that are easy to understand (i.e., high quality explanations) and hinted at the benefits of providing several languages in UAS, which might be interpreted as a form of individualization. These insights may inform the design of UAS in several areas and also inspire further research. For instance, future studies might develop measurement instruments and validate their items for perceived error reduction, perceived explanation quality, perceived traceability, and perceived individualization. With these measurement instruments, existing and future UAS might be evaluated and relationships of these constructs with PU and PEOU might be analyzed in confirmatory study settings. As for our own prototype, the discovery of these design features for instance led us to also include explanatory videos in the software, since explanations have been pointed out as important for both PU and PEOU. In addition, we also included the ability of the system to detect several errors at the same time, which is in line with the discovered importance of error reduction. Last, we intend to add a German version of the UAS as was requested by participants.

Besides these findings, we provide evidence that PEOU and PU have a significant impact on the ITU of UAS, thus underpinning the use of the TAM in the field of UAS. Hence, we propose that future research should also more strongly engage in identifying design features that increase both PEOU and PU in the field of UAS. With these attempts to further improve UAS, we might be able to harness their full potential to enhance user experiences in IS.

2.3 Essay: Increasing Information Visualization Compliance in Self-Service Business Intelligence with User Assistance Systems

Authors:	Michael Schelkle Christian Karl Grund Lena Anja Eleonore Aurnhammer Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg michael.schelkle@wiwi.uni-augsburg.de christian.grund@wiwi.uni-augsburg.de lena.aurnhammer@student.uni-augsburg.de
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2.3.1 Abstract

Self-Service Business Intelligence (SSBI) is increasingly used in organizations. While enabling laypersons in report design to create their own reports in a timely manner, studies show that Business Information Visualization (BIV) is often inappropriately applied in these reports. This may lead decision makers to wrong conclusions. As a result, companies start to establish BIV governance frameworks, which employees are expected to comply with when designing reports. For this, they often provide employees with documentations about which guidelines to comply with. However, since employees may perceive this as additional effort with limited benefit, they may opt to simply not comply. If they are instead equipped with software that provides the functionality to comply, this software often lacks a description of the benefits of this compliance. To overcome this, user assistance systems (UAS) could be used, since they may both reduce the effort to comply as well as describe the usefulness of compliance. To investigate this issue, we developed a prototypical UAS for BIV, suggest a design for a laboratory experiment, and

present findings from a first preliminary study. Results indicate that using UAS for BIV may lead to increased perceived ease of use and perceived usefulness of complying with BIV guidelines.

2.3.2 Problem Identification and Research Objective

To design business reports, Self-Service Business Intelligence (SSBI) is increasingly utilized in organizations (Bange et al., 2017). Here, laypersons in report design (e.g., business users) may use multiple features (e.g., visualizations) to develop their own business reports in a timely manner and share them with decision makers (Poonnawat & Lehmann, 2014). Due to their lack of report design knowledge, however, they often do not correctly apply Business Information Visualization (BIV) within their SSBI reports (Beattie & Jones, 2008; Eisl et al., 2015), which leads to wrong impressions due to a distorted perception (Arunachalam et al., 2002). Thus, decision makers who receive and rely on these delusive business reports may be misled and conclude inappropriately (Arunachalam et al., 2002; Beattie & Jones, 2008). To avoid these negative outcomes, approximately 75% of companies strive for a standardized reporting (Riedner & Janoschek, 2014). In doing so, they often establish BIV governance frameworks in the organization, which employees are expected to comply with when designing business reports (Bange et al., 2017; Gluchowski, 2014; Russom, Stodder, & Halper, 2015). For this, they often provide employees with documentations about which guidelines to comply with. However, since employees may perceive this as additional effort with limited benefit, they may opt to simply not comply (Riedner & Janoschek, 2014). If they are instead provided with software that provides the functionality to comply, this software often lacks a description of the benefits of this compliance (e.g., Chart-me XLS (Gerths, 2018)), which in turn may reduce the intention to comply with BIV guidelines. Possible consequences of this lack of assistance with complying and explaining benefits of compliance are frustration and low efficiency of employees, resulting in overall dissatisfaction (Coch & French, 1948).

It is hence imperative to strive for a solution that makes it both easy for employees to comply with BIV guidelines and raises their understanding of the usefulness of complying with them at the same time. Due to their various applications, a promising approach to achieve these goals is the use of user assistance systems (UAS) (Ludwig, 2015). They help users to perform their tasks better (Maedche et al., 2016) and hence, may increase the perceived ease of use of complying with BIV guidelines. In addition, when UAS are equipped with informative explanations as to why suggestions are made, they may raise an understanding of the perceived usefulness of complying with BIV guidelines (Morana et al., 2017). According to the technology acceptance model (TAM) introduced by Davis (1986), this may in turn lead to an increased intention to comply with BIV guidelines.

In this study, we hence introduce a design science research (DSR) project that aims to develop a UAS that supports employees in complying with BIV guidelines. During the first design cycle, we focused on describing the development of a prototypical artifact, the “BIV Assistant” (Schelkle, 2017). With this current study, we aim to investigate how UAS for BIV may affect the intention to comply with BIV guidelines in management reporting. Having conducted a systematic literature search, based on our sample, we could not identify prior research that explicitly concerns questions whether UAS may actually foster the intention to comply with guidelines (see section 2.3.3). Therefore, we set out to evaluate a prototypical UAS for BIV to answer the following research question:

RQ: To what extent do UAS affect the intention to comply with BIV guidelines in management reporting, in particular in an SSBI environment?

To achieve this, we aim to evaluate this prototypical UAS for BIV in a laboratory experiment. Herewith, we follow the call of Maedche et al. (2016) to study the effects of UAS in the information systems (IS) domain. This research suggests an experimental design for our planned evaluation and provides findings from a preliminary study.

The remainder of this paper is structured as follows. Section 2.3.3 discusses related work followed by the terminology and theoretical background in section 2.3.4.

Section 2.3.5 briefly describes the functionality and design of the artifact. The experimental setting and first evaluation results are presented in section 2.3.6. The paper closes with a conclusion and outlook for future research possibilities.

2.3.3 Related Work

To see whether UAS are used to foster acceptance of and intention to comply with guidelines, knowledge and solutions from prior literature have to be discussed (Peffers et al., 2007). Hence, we conducted a structured literature review drawing on the taxonomy of Cooper (1988) (see Table 1).

Table 1: Taxonomy of Literature Reviews proposed by Cooper (1988)

Focus	Research Outcomes	Research Methods	Theories	Applications
Goal	Integration	Criticism	Central Issues	
Perspective	Neutral Representation	Espousal of Position		
Coverage	Exhaustive	Exhaustive & Selective	Representative	Central/Pivotal
Organization	Historical	Conceptual	Methodological	

We *focus* on the identification of research outcomes on compliance with guidelines by using UAS as applications. The *goal* is to identify central issues in prior research that investigate UAS, which are used to affect the intention to comply with predefined BIV guidelines. Since our aim is to identify existing UAS, which evaluate the intention to comply with guidelines, we adopt a neutral *perspective*. Focusing on UAS as well as BIV as central aspects, we follow a *pivotal* approach. The search is *organized* conceptually, i.e., studies addressing the same idea, UAS used for compliance, appear together.

Since studies related to BIV are fundamentally multidisciplinary (Ware, 2004), we included literature from prior research in computer science and human visual perception

(IEEE Xplore and ScienceDirect) as well as business and management (Emerald Insight) in our literature search. To reflect the AIS Senior Scholars' Basket of Journals and important conference proceedings in the IS field, we added the AIS Electronic Library. To complement the search, we included specific management accounting and IS journals (i.e., HMD Praxis der Wirtschaftsinformatik, Journal of Management Accounting Research, Journal of International Financial Management, and Accounting and Management Accounting Quarterly). We conducted a keyword search comprising title, abstract, and keywords applying the search term *"User Assistance System" OR "User Assistant" OR "User Support System" OR "Assistenzsystem"* to reveal literature in the above-mentioned outlets. As a result[1], *49* articles that deal with UAS could be identified. These range from assistance in healthcare (e.g., Henkemans, Neerincx, Lindenberg, and van der Mast (2006)) and ambient assisted living (e.g., Schneider, Stahl, and Wiener (2016)) to education (e.g., Carlier and Renault (2010)) and many more. However, only one article is related to the information visualization domain and discusses a UAS that suggests to users different mappings between their data and possible visualizations (Guettala, Bouali, Guinot, & Venturini, 2012). Although this study shows the potential of using UAS for BIV, compliance with specific BIV guidelines is not addressed. Since we could not identify literature that addresses UAS and compliance directly, we chose to draw on aspects of acceptance, which might indicate compliance characteristics to some extent. Six out of the 49 articles are related to acceptance. Four articles present technological aspects of acceptance, such as the importance of dialogues (Henkemans et al., 2006), the acceptance of augmented reality (Bleser et al., 2011), the acceptance of smart watches versus mobile phones among dementia patients (Schneider, Reich, Feichtenschlager, Willner, & Henneberger, 2015), or pilots accepting a new cockpit assistance system due to its features (Onken & Walsdorf, 2001). The remaining two articles discuss an algorithm for a lecture allocation system at a university, in which students may accept the assigned lecture (Matsuo & Fujimoto, 2005a, 2005b).

[1] Due to length limitations, we are not able to list all identified references. The list can be provided upon request.

As a result, although some papers address aspects of acceptance, we could neither identify studies that discuss UAS with a focus on compliance in general, nor how UAS may affect the intention to comply with BIV guidelines. Although there might be relevant publications in other outlets, we suppose that our literature review has a satisfying degree of comprehensiveness, since researchers argue that a search can be terminated when the authors are confident of the novelty of the identified area (Boell & Cecez-Kecmanovic, 2010). Hence, we claim that our search shows a research gap that we intend to bridge with our study.

2.3.4 Terminology and Theoretical Background

When information visualization technologies are used to visualize business information (e.g., charts or tables) it is referred to as BIV (Tegarden, 1999). Hence, BIV is the use of computer-supported interactive visual representations of business data to amplify cognition for improved decision making (Bačić & Fadlalla, 2016). This involves defining graphical elements and their relationships to display relevant information (Al-Kassab et al., 2014).

To establish a theoretical underpinning for how UAS might affect the intention to comply with BIV guidelines, we may first look at previous work on compliance in IS literature. A domain within IS that strongly focuses on user compliance is security, as there are many security policies that employees are expected to comply with in order to prevent organizations from potentially dire consequences (Bulgurcu, Cavusoglu, & Benbasat, 2010). In this context, it is argued that when it comes to an individual's decision whether to comply with such policies, they take into account both the benefit of complying with the policy as well as the cost of complying with the policy (Bulgurcu et al., 2010). The reasoning for this is rooted in rational choice theory that posits that individuals take these parameters into account for any decision at hand (McCarthy, 2002; Paternoster & Pogarsky, 2009). Hence, in our context, individuals might also trade off their personal benefit of complying with BIV guidelines as well as the effort caused by complying with these guidelines. According to the theory of planned behavior, this has an effect on their attitude towards complying with BIV guidelines which in turn may influence the intention to comply with BIV guidelines (Ajzen, 1991; Fishbein & Ajzen, 1975). Additional important constructs that affect the intention to comply with security policies are self-efficacy to comply and normative beliefs (Bulgurcu et al., 2010). Self-efficacy to comply describes whether individuals believe they have the abilities and knowledge to comply with the policies whereas normative beliefs express social pressure to comply with these policies. Again, in our context, we expect to observe effects of self-efficacy with regard to complying with BIV guidelines as well as social norms that urge individuals to comply with BIV guidelines.

A prominent theoretical framework that ties these streams of thought together is the TAM (Davis, 1986). It postulates that an individual's intention to use a system (or in our case to comply with BIV guidelines) is determined by perceived usefulness and perceived ease of use (Davis, 1986). Perceived usefulness is defined as the extent to which a person believes that using a particular system will enhance job performance (Davis, 1986), which might in our case be interpreted as the benefit individuals expect from complying with BIV guidelines. The degree to which a person believes that using a particular system will be free of physical and mental effort is defined as perceived ease of use (Davis, 1986), which in our case refers to the individual's cost or effort of complying with BIV guidelines. Thus, when perceived ease of use (i.e., little effort to comply with BIV guidelines) and perceived usefulness (i.e., benefits from complying with BIV guidelines) are high, individuals have a high intention to use a system, or in our case, intention to comply with BIV guidelines.

One promising approach to increase the aforementioned antecedents of the intention to comply with BIV guidelines is using UAS. They guide users (e.g., management accountants) while performing a specific task (e.g., designing business charts) (Maedche et al., 2016), thus fostering perceived ease of use of the task at hand. Since UAS provide guidance or advice on a topic (Maedche et al., 2016), for example on how to adequately apply BIV, they might also foster perceived usefulness of complying with BIV guidelines, as the reason why to use them and what benefits this compliance might have are shown. In addition, this may foster self-efficacy about how to appropriately design business reports. Since SSBI users are at some point novices in report design, they are likely to have a low reporting-related self-efficacy (i.e., the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations (Bandura, 1995)) to design non-misleading reports. Hence, we also investigate how UAS may increase their perceived BIV related capabilities and thus their self-efficacy. Although normative beliefs in general play a role for the intention to comply with BIV guidelines, we do not expect a UAS for BIV to influence social pressure to comply with BIV guidelines, as accepting the system's recommendations is the users' decision. We hence propose the following hypotheses:

H1: Using UAS for BIV increases the intention to comply with BIV guidelines.

H2: Using UAS for BIV increases the perceived usefulness of complying with BIV guidelines.

H3: Using UAS for BIV increases the perceived ease of use of complying with BIV guidelines.

H4: Using UAS for BIV increases reporting-related self-efficacy.

In line with the propositions introduced in the TAM, we also expect to see positive relationships between the intention to comply with BIV guidelines and its antecedents. We thus propose:

H5: There is a positive relationship between the perceived usefulness of complying with BIV guidelines and the intention to comply with BIV guidelines.

H6: There is a positive relationship between the perceived ease of use of complying with BIV guidelines and the intention to comply with BIV guidelines.

H7: There is a positive relationship between reporting-related self-efficacy and the intention to comply with BIV guidelines.

To investigate these hypotheses, we will propose an experimental design as well as results from a preliminary study in section 2.3.6. First, we will briefly describe the functionality and design of the artifact

2.3.5 Functionality and Design of the Artifact

2.3.5.1 Desired Functionality

The desired functionality of our UAS called "BIV Assistant" is divided into three steps (Schelkle, 2017). First, it screens business charts for inadequate BIV. This might for example be a truncated axis that exaggerates the magnitude of a trend. Second, a warning is prompted to the user that explains the visual deficiency according to BIV guidelines from the International Business Communication Standards (IBCS) Association. These guidelines describe how to assure appropriate BIV, referring to prominent information visualization literature (Hichert & Faisst, 2015). In consequence, users may perceive adequate BIV as being useful to support decision-making, thus fostering perceived usefulness of complying with BIV guidelines. Last, the user decides if the BIV Assistant automatically amends the inadequate BIV by applying the guideline presented in the previous step. Since complying with BIV guidelines in this case is reduced to the click of a button, it may result in increased perceived ease of use. According to the TAM, this may lead to an increased intention to comply with BIV guidelines.

The current prototype of the BIV Assistant detects four different misleading visualization patterns (i.e., truncated axis, inverted timeline, filtered elements on the ordinate axis, and differently scaled axes) (Schelkle, 2017). This refers to Courtis (1997) as well as Beattie and Jones (2008) who examine annual reports on inadequate visualizations and illustrate misleading patterns along with improved versions.

2.3.5.2 Design of the Artifact

With its characteristics, the BIV Assistant provides guidance to users on how BIV guidelines have to be applied. Therefore, we draw on the integrated taxonomy of guidance design features proposed by Morana et al. (2017) to assure a comprehensive design of the artifact.

This taxonomy characterizes the dimensions audience, target, mode, directivity, invocation, timing, intention, content, format, and trust-building (Morana et al., 2017).

SSBI is intended to be used by any employee who has to conduct business analyses and design business reports, no matter their expertise. Therefore, we primarily focus on BIV novices as *audience*, since they appear more likely to need assistance.

To increase the perceived ease of use, the *target* of the BIV Assistant is to facilitate to comply with BIV guidelines, which can be seen as engaging in a given activity (Morana et al., 2017). In our case, the BIV guidelines are determined by the IBCS (see above). Hence, as *mode* of assistance we draw on a predefined framework. Since the task to comply with these guidelines can be complex, the BIV Assistant *directs* the user to adhere to the IBCS, which may result in a perceived ease of use of complying with BIV guidelines. UAS ought to reduce users' mental working memory and should not additionally burden the user with interruptions at the wrong time (Gregor & Benbasat, 1999). Hence, a user-triggered *invocation* and retrospective *timing* is chosen. Since the BIV Assistant does not constantly interrupt the multi-staged BIV process (Ware, 2012), users remain in their thought process and receive assistance upon request.

To increase the perceived usefulness of complying with BIV guidelines, the BIV Assistant shows warning messages and thus informs what elements of the visualization can lead to a distorted perception (e.g., avoid truncated axes (Hichert & Faisst, 2015)). The *intention* of the warning is twofold. First, it is used to clarify why a specific inappropriately visualized element is misleading. Second, it provides working explanations and expert knowledge (i.e., terminological *content*), drawing on the know-how from the IBCS. The presentation *format* of these warnings is a combination of text and image. For the textual description of the misleading element, the BIV Assistant displays explanations provided by the IBCS. Since textual descriptions may have some limitations in terms of comprehension (Kuechler & Vaishnavi, 2006) and bear language barriers (Morana et al., 2017), we complement the warning with an image of the improved business chart.

Trust in assistance, such as receiving guidance on why and how to comply with BIV guidelines, can have a strong effect on users' intention to follow suggestions (Morana et al., 2017). Therefore, we intend to proactively *build trust* and hence increase reporting related self-efficacy by applying guidelines from the IBCS, which describe how to assure appropriate BIV.

In summary, the design aspects, which may lead to an increased perceived ease of use and perceived usefulness of complying with BIV guidelines as well as increased reporting self-efficacy may help to foster the intention to comply with BIV guidelines.

2.3.6 Experimental Evaluation

2.3.6.1 Evaluation Design, Participants, and Procedure

To evaluate the artifact's performance, it should be evaluated against its research objectives (Peffers et al., 2007). With this study, we aim to suggest an experimental design that helps to gain insight to what extent UAS affect the intention to comply with BIV guidelines, in particular in an SSBI environment. In addition, we performed a preliminary study to investigate whether the suggested design works. To determine the evaluation method, we refer to Venable et al. (2012). We chose a laboratory experiment, since the artifact already has been developed (i.e., ex post evaluation) and since an artificial evaluation environment provides the benefit of controlling for possibly confounding variables as well as allows measuring the efficacy of an artifact. More precisely, we chose a within-subject design for this experiment, where participants may experience report design both with and without using a UAS for BIV. Although within-subject designs are susceptible to possible learning effects (Charness et al., 2012), we decided to follow such a design, since potential learning effects are of minor relevance when investigating the effects of UAS on intention to comply with BIV guidelines. Moreover, a within-subject experiment requires less participants compared to between-subject designs (Lazar et al., 2010), which can be a relevant aspect for conducting a preliminary study. Since studies indicate that managers and students behave similarly (Bolton et al., 2012), 14 university students (4 female, 10 male, average age: 22) of an IS course participated in this preliminary study.

To analyze the relationship between using a UAS for BIV (i.e., independent variable) and the intention to comply with BIV guidelines (i.e., dependent variable), we differentiate between two measurement settings. In both settings, participants have the task to identify inadequate BIV in four different business charts according to the IBCS guidelines. The settings of the measurements differ in the type of assistance, however. Since BIV guidelines are typically provided in written documents (e.g., Few (2012), Ware (2012), Hichert and Faisst (2015)), the only assistance allowed in the first setting were the IBCS guidelines, which are published via the website of the IBCS Association. In the second setting, participants could use our BIV Assistant to fulfil the requested task.

The experiment was structured in multiple stages (cf. Figure 1). First, participants were introduced to the experiment and got a short training on how to access the BIV guidelines of the IBCS Association website. In the next step, they had to accomplish the above described task according to the first setting. After its completion, they were asked to answer multiple questions on their intention to comply with BIV guidelines. For this, questionnaires with validated items from prior research (Venkatesh & Davis, 2000) were translated into German and adapted to IBCS guidelines. For example, “Assuming I have access to the system, I intend to use it” was adapted to “Assuming I have access to the IBCS guidelines, I intend to use them.” Due to the constructs of interest, the questions from Venkatesh and Davis (2000) comprised items for measuring the intention to use, which in our case is the intention to comply with BIV guidelines (ITC), perceived usefulness (PU), and perceived ease of use (PEOU). For measuring self-efficacy (SE), we draw on items from Spannagel and Bescherer (2009), who focus on scales of computer user SE. All items were measured on a 7-point scale, where 1 = strongly disagree and 7 = strongly agree.

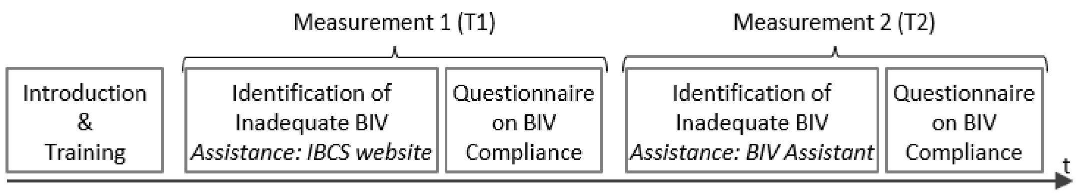

Figure 1: Design of the Within-Subject Experiment

To reduce potential learning effects for the second measurement, we slightly modified the business charts with inadequate BIV and changed the sequential order for the second setting. Here, participants had to fulfil the described task with the opportunity to use our BIV Assistant. To assess constructs related to intention to comply with BIV, the same questions as in the first setting were used.

2.3.6.2 Results of the Preliminary Study

Venkatesh and Davis (2000) as well as Spannagel and Bescherer (2009) show a high reliability (i.e., Cronbach's α) of their measurement scales. However, as we slightly adopted and translated these items, we computed the reliability of our scales to assure an appropriate basis for our analysis using SPSS version 24. The results of this reliability analysis are satisfactory and depicted in Table 2.

Next, we analyzed whether the intention to comply with BIV guidelines as well as its antecedents can be enhanced by the usage of our BIV Assistant. As we used a within-subject design, we conducted dependent t-tests and compared the differences between means of the variables under the conditions at measurement 1 (T1) and measurement 2 (T2). Any significant difference observed indicates an effect of using our BIV Assistant. The result of this analysis shows that means of all variables increased from T1 to T2. In particular, the increase in report SE was highly significant, and increases in PEOU as well as in PU were marginally significant. However, although there was also an increase in ITC, it was not significant. Hence, while not finding support for H1, we found support for hypotheses H2-4. The results of this analysis are presented in Table 2.

Table 2: Reliability of Scales and Dependent T-Test Results ((*) p<0.10, **p<0.01)

		Cronbach's α		Dependent t-test			
Scale	n	T1	T2	Mean at T1	Mean at T2	p	H
ITC	14	0.96	0.69	5.32	5.71	0.290	(H1)
PU	14	0.86	0.87	4.82	5.50	0.052 (*)	(H2)
PEOU	14	0.81	0.94	4.64	5.62	0.061 (*)	(H3)
SE	14	0.84	0.85	4.36	5.14	0.002 **	(H4)

To examine if the propositions from TAM hold in the context of BIV guideline compliance, we conducted a multiple linear regression analysis to compute the influence of the independent variables PU, PEOU, and SE on the dependent variable ITC. Measurements where used from T2, as we intended to see whether the propositions from TAM hold after using our artifact. The R^2 for the overall model was .90 (adjusted R^2=.88) which indicates a high goodness-of-fit according to Cohen (1988). PEOU, PU, and SE were able to statistically significant predict ITC, with $F(3,10)=32.2$, $p<.001$. However, regression coefficients differ in their ability to predict ITC. While PEOU significantly predicts ITC ($\beta=.70$, $p<.05$), PU was not significant ($\beta=.30$, $p=.19$), which is also the case for SE ($\beta=-.02$, $p=.86$). Hence, while finding support for H6, this is not true for H5 and H7. These findings indicate, that in a BIV context, PEOU is especially important to foster ITC. These outcomes are depicted in Figure 2.

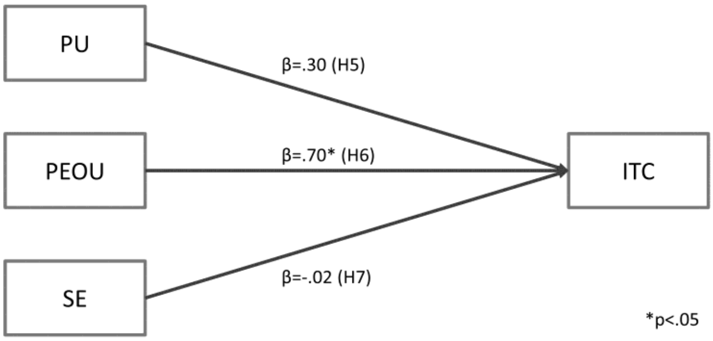

Figure 2: Regression Analysis of Antecedents of ITC

These first results show that using the BIV Assistant may lead to increased perceived ease of complying with BIV guidelines, perceived usefulness of complying with BIV guidelines, and report-related self-efficacy. In addition, they indicate that perceived ease of complying with BIV guidelines appears to be the most important antecedent of intention to comply with BIV guidelines. In the following, we provide a conclusion on these findings and outline possibilities for future research.

2.3.7 Conclusion and Future Research

Following the DSR activities proposed by Peffers et al. (2007), we showed that using UAS may impact compliance in a BIV context. Since we could not identify studies that examine whether UAS may affect the intention to comply with BIV guidelines based on our literature review, we proposed a design of a UAS that aims to improve this intention and introduced the BIV Assistant as a prototypical implementation. According to Briggs and Schwabe (2011), this is a DSR contribution of the applied science and engineering category, since we provide an instance of a generalizable solution in form of a proof-of-concept prototype. The second DSR contribution provided by this study is experimental research, which leads to hypotheses, experimental designs, and analyzed data sets (Briggs & Schwabe, 2011). Based on a within-subject experiment, we provide indications that the BIV Assistant has a positive impact on complying with BIV guidelines. In addition, the findings indicate that in a BIV context, perceived ease of use of complying with BIV guidelines is especially important to foster the intention to comply with guidelines.

Of course, this study only draws on data from a small preliminary study. However, based on the statistically significant findings provided by this study, we aim to substantiate our results in a next design cycle as proposed by Hevner (2007), using the proposed evaluation design. For this purpose, we intend to further develop the existing prototype to reflect a higher number of BIV guidelines, and seek to also evaluate it among actual decision makers in organizations.

Moreover, we also aim to analyze to what extent UAS and their design features can help to train BIV guidelines, since self-efficacy may also be influenced by the degree of a user’s knowledge on how to appropriately design reports. With our BIV Assistant, we hope to provide a novel and fruitful avenue for improving BIV in SSBI and thus decisions based on the resulting reports.

2.4 Essay: An Assistance System to Support Learning of Business Information Visualization Guidelines

Authors:	Michael Schelkle Christian Karl Grund Carina Preissler Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg michael.schelkle@wiwi.uni-augsburg.de christian.grund@wiwi.uni-augsburg.de carina.preissler@student.uni-augsburg.de
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2.4.1 Abstract

Creating business reports is a main task of the management accounting domain. Unfortunately, decision makers may conclude inappropriately as these reports are often delusive due to incorrectly designed visualizations. One reason for this is a lack of profound knowledge in applying business information visualization (BIV) guidelines. Since this knowledge has rarely been taught, companies need to train their employees for instance via work-integrated learning. To achieve this, user assistance systems (UAS) may be a promising approach. Since feedback is one of the most powerful influences on learning, the overarching goal of our design science research project is to gain insight to what extent UAS support feedback-based learning of BIV guidelines. Building on feedback intervention theory, we introduce a prototypical UAS that aims to achieve this goal. Hence, we contribute to research by providing a proof-of-concept prototype of a UAS that fosters learning BIV guidelines.

2.4.2 Problem Identification and Research Objective

A central task in the management accounting domain is to create business reports as a means for decision support (Pollmann & Rühm, 2007). Studies show, however, that visualizations in these business reports are often misleading (e.g., Beattie and Jones (2008), Courtis (1997)). In consequence, decision makers who receive and rely on these delusive business reports may conclude inappropriately (Beattie & Jones, 2008). To avoid this, business information visualization (BIV) guidelines are considered helpful and are on the one hand gaining relevance over the last recent years (Riedner & Janoschek, 2014). On the other hand, these guidelines are known by relatively few who need them (Few, 2012), since BIV knowledge has rarely been taught in school or higher education when studying business administration (Kohlhammer et al., 2013). Hence, companies need to train their employees (i.e., management accountants) on the job (Kohlhammer et al., 2013). However, report designers complain about a lack of training opportunities for BIV (Riedner & Janoschek, 2014). As traditional training methods (e.g., seminars) seem to be declining since the year 2010 and more novel methods (e.g., work-integrated learning) are increasingly accepted (Federal Statistical Office of Germany, 2017), training possibilities for the latter should be fostered.

Besides guiding users while performing a specific task (Maedche et al., 2016), user assistance systems (UAS) are a possibility that can be used for work-integrated learning (Senderek & Geisler, 2015). Hence, they appear to be a promising approach to support learning BIV guidelines. Such UAS may for example screen business charts and give the report designer feedback on inappropriately designed elements (e.g., truncated axes). Since feedback is one of the most powerful influences on learning (Hattie & Timperley, 2007), the overarching goal of our research project is to gain insight to what extent UAS support feedback-based learning of BIV guidelines in a work-integrated learning environment. To evaluate this, a UAS that provides feedback to foster learning BIV guidelines is needed. However, having conducted a systematic literature review, we could not identify such UAS in prior literature (cf. section 2.4.3). Hence, following the design science research (DSR) approach proposed by Peffers et al. (2007), in a first step a UAS for training BIV guidelines had to be developed. Thus, the research objective of this study is:

RO: Design a software-based user assistance system that fosters feedback-based learning of business information visualization guidelines.

Herewith we intend to contribute to study the effects of assistance systems in the field of information systems research as suggested by Maedche et al. (2016) and provide a specific solution in the form of a prototype for the management accounting domain.

2.4.3 Related Work

To see whether knowledge about UAS that foster feedback-based learning already exists, we conducted a systematic literature review as suggested by Webster and Watson (2002). To reflect the multidisciplinarity of information visualization, computer science, human visual perception and the application domain management accounting are considered (Ware, 2012). Hence, we included important outlets and databases such as Science Direct, AIS Electronic Library (AISeL), the conference proceedings of the DESRIST, and the journal HMD Praxis der Wirtschaftsinformatik. To complement the search with the domain of management accounting, we included the outlets Emerald Insight, Management Accounting Research, Journal of Management Accounting Research, and the Journal of International Financial Management & Accounting. The search term comprised “assistance system”, “education”, “feedback”, and closely related terms. With this search, we identified 8 relevant research articles. To enhance the literature sample, we conducted a backward search and identified 7 additional papers, resulting in a total of 15 relevant articles. Due to length limitations, only an excerpt of these articles is briefly discussed. As we could not find UAS that assist through feedback-based learning of BIV guidelines, we classify the identified UAS in assistance for educating languages, science, or process guidance. UAS for language education are for example a Portuguese Language learning system called TAGAREL (Amaral, Meurers, & Ziai, 2011) and a UAS that teaches Persian Grammar (Mirzaeian, Kohzadi, & Azizmohammadi, 2016). Education in science is for instance provided by Betty's Brain, a UAS that teaches middle school science students about river ecosystems (Leelawong & Biswas, 2008). The UAS AMT is a step-based tutoring system that supports learning a modelling language (Zhang et al., 2014). The aspect of process guidance is reflected with the ITSM ProcessGuide, which supports the understanding of process models and leads to an efficient execution of a process (Morana, Gerards, & Maedche, 2015). Although the identified UAS support users in learning specific tasks, none of the studies from prior research covers the aspect of a software that assists feedback-based learning of BIV guidelines in a work-integrated environment. While there might be relevant literature in other outlets, we suppose that our review has a satisfying degree of comprehensiveness and claim that we show a research gap that we intend to bridge.

2.4.4 Terminology and Theoretical Background

BIV is the use of computer-supported interactive graphical representations of business data to amplify cognition for improved decision making (Bačić & Fadlalla, 2016). This involves defining graphical elements and their relationships to display relevant information (Al-Kassab et al., 2014), which is this study's focus. To convey BIV knowledge, guidelines from current literature (e.g., Few (2012), Hichert and Faisst (2017)) may be used (Ware, 2012). Hichert and Faisst (2017) propose a framework called International Business Communication Standards (IBCS), which comprises knowledge from well-known BIV authors and showcase comprehensively inadequate BIV examples alongside their proposed corrections. Hence, we use these guidelines for our UAS.

Feedback can be defined as information provided by an agent (e.g., teacher, peer, book) regarding aspects of one's performance (Hattie & Timperley, 2007). To characterize how feedback relates to learning, we refer to feedback intervention theory (FIT) introduced by

Kluger and DeNisi (1996). FIT is a well-documented framework (Hysong, Teal, Khan, & Haidet, 2012), which comprises knowledge from various theories (e.g., action identification theory or goal setting theory). Drawing from action identification theory (Vallacher & Wegner, 1987), FIT posits that feedback in general has three possible outcomes. It provides information that may either lead to learning (i.e., focal task detail level), motivation (i.e., focal task level) or reflection about oneself (i.e., meta-task level). Since feedback highly influences task learning processes and task motivation processes, we focus on these two aspects.

According to FIT, feedback that contains a correct solution affects learning (Kluger & DeNisi, 1996). Thus, information technology that helps to perform tasks better (e.g., UAS (Maedche et al., 2016)) has to provide corrective feedback to positively influence learning.

Although corrective feedback directly influences learning processes, the origin for learning is often on the motivational level (Kluger & DeNisi, 1996). Therefore, aspects of motivational processes have to be considered in our study. For these processes, FIT refers to goal setting theory introduced by Latham and Locke (1991). Goal setting theory implies that specific goals lead to a higher level of task performance than abstract goals (Latham & Locke, 1991). With UAS, one may be able to specify an overall goal in a specific situation when a report creator designs or redesigns a given business chart. Thus, UAS can increase goal specificity by providing feedback that describes the steps to be performed to reach the desired goal.

A high level of task performance is only valid when a person is committed to the goal and has the ability (i.e., task knowledge and skills) to attain it (Latham & Locke, 1991). According to Latham and Locke (1991), goal commitment can be enhanced when a person believes that achieving a goal is possible, which raises the person's expectancy of success (i.e., self-efficacy). Increasing goal commitment and self-efficacy may be especially important for difficult tasks. Complying with BIV guidelines can be regarded as such, since studies indicate that assistance and learning opportunities are needed to cope with this task (Kohlhammer et al., 2013; Riedner & Janoschek, 2014). According to goal setting theory, training and information of past success can positively influence goal commitment and self-efficacy (Latham & Locke, 1991). Hence, UAS should provide training possibilities and information about past success. According to the theoretical considerations outlined, we conclude that UAS may positively influence learning, either via corrective feedback or via motivational aspects.

2.4.5 Design of the Software Prototype

Drawing from the knowledge of a research project for which we introduced a UAS to evaluate compliance with BIV guidelines (Schelkle, 2017), we developed a new prototype for this current research project. Since Microsoft Excel is still widely used for reporting (Gräf, Isensee, Kirchmann, & Leyk, 2013), we developed the new prototype as an Excel Add In called the "BIV Learning Assistant". We focused on column and bar charts, since these account for approximately 56% of all visualizations in annual reports of companies, which are listed on the German stock exchange DAX 30 (Eisl et al., 2015). Since, this study's focus is on the correct definition of graphical elements and their relationships, we conducted a literature search to derive the top misleading graphical elements to be considered. As result, 15 relevant articles could be identified (e.g., Beattie and Jones (2008), Courtis (1997)) and revealed incorrectly scaled axes, non-zero axis, inappropriately colored elements, and pseudo-3D objects to be most important. Hence, the BIV Learning Assistant can verify these four misleading visualization elements.

Referring to the theoretical background, the BIV Learning Assistant provides design elements for specific goals, corrective feedback, training opportunities and information about past success in order to foster learning BIV guidelines.

After activation, the assistant screens a selected business chart for inappropriately visualized elements (e.g., truncated axes). In case there are such elements, the report designer receives a feedback message that specifies the number of violations. Next, the BIV Learning Assistant displays the current version of the business chart alongside a corrected version of the same business chart to enable a comparison and hence presents a specific goal to the report designer. In order to display the corrected version of the business chart, the BIV Learning Assistant examines all graphical elements for appropriateness. If there is a misleading element, such as a truncated axis, the BIV Learning Assistant automatically corrects these elements and displays the corrected version as the target state. For example, in case of a truncated axis, our assistance system checks, if the starting value of the axis is zero and if not, it automatically sets it to zero.

Since textual descriptions of a visual object may have limitations in terms of comprehension (Kuechler & Vaishnavi, 2006), we chose images to specify the goal. As effective feedback should provide cues (Hattie & Timperley, 2007), our UAS also provides cues to identify incorrect elements (e.g., “Are truncated axes useful for decision making?”)

Based on the provided information, report designers may opt to correct the actual business chart themselves or demand further assistance. In case of further assistance, the BIV Learning Assistant provides corrective feedback by citing the violated IBCS guidelines, which explain why the inappropriate elements can be misleading. Since video-assisted instructions are an effective form of feedback (Hattie & Timperley, 2007), report designers can opt to watch a video about how to correct the chart to comply with the IBCS. Training opportunities are provided, since report designers can decide at every feedback step if they would like to amend the current status of the business chart or if they demand further feedback. After each attempt of correcting the business chart, the report designer can ask the BIV Learning Assistant to verify the amended business chart and to provide feedback based on the new status. Every time report designers ask the BIV Learning Assistant to verify the business chart, data about the business chart is collected. Hence, upon request, the BIV Learning Assistant can provide information about past success. This comprises the number of attempts to correct the business chart including the number of incorrect elements in both visual and textual manner. We specifically focused on information that relates to the report designer’s own performance solely, since comparisons to other persons or grades as performance indicators may impede learning (Kluger & DeNisi, 1996).

2.4.6 Proposed Evaluation

A typical training situation may be that a company provides written learning materials on a specific topic to employees who have to learn autonomously. Hence, we aim to thoroughly evaluate our BIV Learning Assistant against using those documents in a between-subject experiment. To analyze the effects on learning outcomes, goal specificity, self-efficacy and goal commitment (i.e., dependent variables) by using the BIV Learning Assistant (i.e., independent variable), we may differentiate between two measurement settings. In both settings, participants (i.e., students from a German university) have the task to identify misleading elements in different business charts referring to the IBCS. However, the settings differ in the way of assistance. Since BIV guidelines are typically written documents (e.g., Hichert and Faisst (2017)), in the first setting, assistance is provided only by a written documentation of the IBCS. In the second setting, participants have to use the BIV Learning Assistant to fulfill the task. After having finished the described task, participants will be asked to answer multiple questions on the dependent variables based on validated items from prior research (e.g., Venkatesh and Bala (2008)). Due to the design of the BIV Learning Assistant, which is deduced from FIT, we expect that using our UAS will positively influence goal specificity, self-efficacy, and goal commitment and hence foster learning BIV guidelines.

2.4.7 Conclusion and Research Outlook

This paper presents the first step of our ongoing DSR project on fostering learning of BIV guidelines using UAS, referring to the DSR activities suggested by Peffers et al. (2007). From a research perspective, we contribute by raising problem awareness and identifying that the development of UAS in the field of BIV is not addressed appropriately, in particular with a focus to foster learning BIV guidelines. Moreover, we contribute to research with the introduced BIV Learning Assistant as a prototypical implementation. This is a DSR contribution of the applied science and engineering category according to Briggs and Schwabe (2011), as we provide an instance of a generalizable solution in form of a proof-of-concept prototype, even so, the current prototype is limited with regard to the number of detectable misleading elements. Hence, as proposed by Hevner (2007), in the next design cycle we intend to further develop our UAS to be able to uncover more misleading elements (e.g., background color). After having developed a finalized prototype, we intend to thoroughly evaluate the BIV Learning Assistant in a between-subject experiment to gain insight to what extent UAS support feedback-based learning of BIV guidelines in a work-integrated learning environment. Hence, with this study we hope to provide a starting point for further research to evaluate the effects of feedback-based learning with UAS with the overarching goal to contribute to better decisions based on appropriate business reports, which is key for the management accounting domain.

2.5 Essay: Designing User Assistance Systems for Learning Business Information Visualization Guidelines: Findings from an Empirical Study

Authors:	Michael Schelkle Christian Karl Grund Carina Preissler Lena Anja Eleonore Aurnhammer Max Hurm Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg michael.schelkle@wiwi.uni-augsburg.de christian.grund@wiwi.uni-augsburg.de carina.preissler@student.uni-augsburg.de lena.aurnhammer@student.uni-augsburg.de max.hurm@student.uni-augsburg.de
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2.5.1 Abstract

Decision makers may conclude inappropriately as business reports are often delusive due to incorrectly designed visualizations. This issue is rooted in a lack of profound knowledge about applying business information visualization (BIV) guidelines. Since this knowledge has scarcely been taught, it is currently a company's responsibility to ensure that employees acquire adequate BIV knowledge. For this, workplace learning may be appropriate, for which user assistance systems (UAS) seem to be a promising approach to foster learning as they can guide users while performing a specific task. Since feedback has proven to be one of the most powerful influences on learning, the aim of this design science research study is to gain insight to what extent UAS support feedback-

based learning of BIV guidelines. We developed a UAS and evaluated its efficacy in a laboratory experiment. Results indicate that participants, who used UAS that aim at fostering learning, were significantly better in acquiring BIV knowledge compared to participants provided with other means of learning assistance. Moreover, we were able to show that UAS may significantly increase knowledge acquisition. Hence, we contribute to literature by providing generalizable findings based on a novel and useful artifact.

2.5.2 Problem Identification and Research Method

A widely discussed issue in the domain of management accounting and business intelligence (BI) is that business reports struggle to achieve their central task: supporting decision makers by providing relevant information and creating business transparency by drawing attention to critical areas and revealing needs for action (Arunachalam et al., 2002; Gräf et al., 2013; Weide, 2009). This is especially true for visualized elements in business reports. Courtis (1997) for example shows in his study that almost 50% of 114 examined reports misrepresent their visualized financial data. Beattie and Jones (1992) revealed that 30% out of 240 business reports illustrate graphs with material measurement distortions. Such improperly designed visualizations may lead to negative effects on decision making (Arunachalam et al., 2002), which has already been proven by experiments that date back to the 1990's. Lawrence and O'Connor (1993) for instance, show in their experimental study that already minor formatting (e.g., omitting horizontal grid lines) can have a significant negative effect on the accuracy of judgmental prediction. Carswell (1991) illustrates another example. Her research findings demonstrate that pseudo 3D-effects are associated with less accurate performance for people (e.g., managers), who attempt to estimate or recall the relative magnitude of displayed values or describe trends (Carswell, 1991). Applying Business Information Visualization (BIV) guidelines when creating business reports may avoid this unfortunate circumstance, which is why they are gaining relevance over the last recent years (Riedner & Janoschek, 2014). However, although research illustrates the negative effects of inadequately visualized business reports and several guidelines for appropriately visualizing business reports exist (e.g., Few (2012), Ware (2012), Tufte (2011), Hichert and Faisst (2017)), it seems that many companies do not apply these guidelines when creating business reports (Al-Kassab et al., 2014; Kohlhammer, Proff, Stahl, & Wiener, 2012; Reiterer, Mann, Mußler, & Bleimann, 2000). This is caused by report designers' deficient BIV expertise (Few, 2012) because BIV knowledge has barely been taught in schools or higher education, in particular when studying business administration (Kohlhammer, 2014). This is why companies need to train their employees (e.g., management accountants) on the job (Kohlhammer, 2014). The problem, however, is that for BIV barely training opportunities exist (Riedner & Janoschek, 2014). In general, traditional training methods (e.g., learning from written documents or participating in seminars) are declining since the year 2010 and more novel methods (e.g., workplace learning) are increasing (Federal Statistical Office of Germany, 2017). Therefore, training possibilities for the latter promise to bear an appropriate solution. Such a training possibility may be user assistance systems (UAS), which might be applied for workplace learning (Senderek & Geisler, 2015) as they guide users while performing a specific task (Maedche et al., 2016) and can be used for various applications (Ludwig, 2015). Since feedback has proven to be one of the most powerful influences on learning (the average effect size of feedback is almost twice the average effect of typical schooling) (Hattie & Timperley, 2007), it seems to be beneficial to combine the advantages of UAS with the possible learning effects of feedback. In the context of learning BIV guidelines, such UAS may for example screen business charts, give the report designer feedback on potential misleadingly designed elements, and provide suggestions on how to correct the errors. Therefore, we set out to contribute to gaining insight to the following research question (RQ):

RQ: To what extent can UAS support feedback-based learning of BIV guidelines?

Aiming at investigating and contributing to solve the outlined challenge, we apply the DSR approach as proposed by Hevner et al. (2004) and Peffers et al. (2007). To find answers to the above RQ, there is the need of a UAS that provides feedback in the context of BIV. Therefore, we suppose applying DSR as methodology to be promising, since we aim to support solving the aforementioned challenges by designing, developing and evaluating an appropriate IS. Providing insights to the outlined has not been done thus far in prior literature (see section related work). Hence, with our findings we may increase the existing body of knowledge within the IS research community. Since we could not identify an adequate UAS in prior literature (Schelkle, Grund, & Preissler, 2018), we provided a first concept of a UAS that aims at conveying BIV guidelines by providing feedback to the user (Schelkle, Grund, & Preissler, 2018). While we developed a first prototypical software artifact called the "BIV Learning Assistant" in a previous iteration of this DSR project (Schelkle, Grund, & Preissler, 2018), the objective of this study is to build on this prior research and evaluate the artifact in an experimental study. Since we aim to foster learning BIV guidelines with a UAS that may be employed in a work-integrated environment, we address a grand challenge in the field of information systems (IS) research proposed by Mertens and Barbian (2015). This grand challenge is concerned with "personalization of instruction and training in business contexts, real-time instruction" and the objective to offer "help (in real-time) when an employee runs into difficulties during a task" (Mertens & Barbian, 2015). In addition, we follow the call of Maedche et al. (2016) to study the effects of UAS in the field of IS research and provide a specific solution in the form of a prototype.

Having discussed the environment including its application domain and problem space, we structure the remainder of this study as proposed by Hevner et al. (2004) and Peffers et al. (2007). Next, we introduce the knowledge base comprised by key terms (section 2.5.3) and related work (section 2.5.4). Section 2.5.5 describes the design, functionality and architecture of the developed artifact. The results of our evaluation are presented in section 2.5.6. The paper closes with a discussion, conclusion and outlook for future research possibilities.

2.5.3 Terminology

2.5.3.1 Business Information Visualization

Card et al. (1999) refer to BIV as "the use of computer-supported interactive visual representations of abstract business information to amplify cognition". Typical examples of such business information are employee turnover statistics or sales goals figures (Bačić & Fadlalla, 2016). Business information has traditionally been visualized for instance in line graphs, pie charts, or bar charts, whereas nowadays multidimensional graphics are increasingly used (Tegarden, 1999). Bačić and Fadlalla (2016) add the aspect of decision-making to the aforementioned and offer a more comprehensive definition of BIV: "the use of computer-supported interactive visual representations of business data to amplify cognition, achieve better data, business, and behavior understanding to improve decision making and business impact" (Bačić & Fadlalla, 2016). This involves defining graphical elements and their relationships to display relevant information (Al-Kassab et al., 2014), which is this study's focus.

A means to convey BIV knowledge are BIV guidelines (Ware, 2012), which may be defined as a general rule, principle, instruction, or piece of advice for the use of computer-supported visual representations of business data to amplify cognition (Grund & Schelkle, 2016). There are already several such guidelines in current literature. For instance those of Few (2012), Tufte (1997) or Hichert and Faisst (2017). The latter offer a framework called International Business Communication Standards (IBCS), which comprises expertise from various well-known BIV authors, such as those mentioned, and showcase comprehensively inadequate BIV examples alongside their proposed corrections (Grund & Schelkle, 2016). This is why we use these guidelines for our UAS.

2.5.3.2 User Assistance Systems

UAS are an interactive information technology component which supports users to perform their tasks better (e.g., learning) (Blutner et al., 2009; Maedche et al., 2016).

They offer recommendations and the user individual has to decide whether to follow the advice (Ludwig 2015). UAS however, do not enforce specific behavior on their users, but guide them while performing a specific task (Maedche et al., 2016). This is key, since UAS do not comprise systems that perform tasks entirely automatically or autonomously on behalf of the user.

2.5.3.3 Feedback and Workplace Learning

Feedback can be defined as information provided by an agent (e.g., teacher, peer, book, parent, self) regarding aspects of one’s performance (Hattie & Timperley, 2007). However, feedback has no effect in a vacuum; to be powerful, there must be a learning context to which feedback is addressed (Hattie & Timperley, 2007). In our case, this learning context are BIV guidelines ought to be learned in a work-integrated environment. This environment may be called workplace learning, which we refer to as the acquisition of professional competence and expertise being engaged in work tasks (Bauer & Gruber, 2007). Workplace learning introduces the idea of simultaneous and integrated working and lifelong learning (Bauer & Gruber, 2007).

2.5.4 Related Work on User Assistance Systems for Conveying Knowledge

2.5.4.1 Methodology for Related Work

Referring to the DSR methodology suggested by Peffers et al. (2007), we next discuss the hitherto existing literature in the field of UAS concerned with conveying knowledge, in particular with UAS that foster feedback-based learning of BIV guidelines. For this, we conducted a systematic literature review that refers to the approach suggested by Webster and Watson (2002) as well as vom Brocke et al. (2015). We followed a search, which is grounded in three sequential steps. First, we conducted a database search. Next, we searched journals and proceedings that were not covered by the database search, and last, we conducted a reference-based backward search. We aimed to reveal representative prior research by including research from the fields of computer science, human visual perception, and management accounting, which is proposed by Ware (2012) when doing studies in BIV. Further, we added the field of IS research to complement our search. To reflect these requirements, we included the databases Science Direct, IEEE Xplore, ACM Digital Library, Emerald Insight, and AIS Electronic Library (AISeL). Further, we considered the proceedings of the International Conference on Design Science Research in Information Systems and Technology (DESRIST), and the journal HMD Praxis der Wirtschaftsinformatik. To complement the search with the domain of management accounting, we incorporated the journals Management Accounting Research, Journal of Management Accounting Research, Advances in Management Accounting, and the Journal of International Financial Management and Accounting. The search term comprised “assistance system”, “education”, “feedback”, and closely related terms, resulting in the search term ("*assistance system*" OR "*tutoring system*" OR "*guidance system*" OR "*wizard*") AND *(train** OR *learn** OR *educat**) AND (*feedback* OR "*formative assessment*"). In summary, we identified with our search in the above databases and journals 8 relevant articles and included 6 additional papers from the backward search. The resulting set of 14 relevant scientific articles will be discussed in the next sections.

2.5.4.2 Description of User Assistance Systems

Our literature review reveals several patterns with regard to the domains they are used as well as with regard to their types of feedback. Even so, Schelkle, Grund, and Preissler (2018) provide a brief summary of some of the identified UAS, we suppose that a more detailed description of UAS that are used to convey knowledge helps for a better understanding of this study. Hence, we adopt and extend the explanations originally presented in (Schelkle, Grund, & Preissler, 2018). Since we could not find UAS that assist through feedback-based learning of BIV guidelines, we classify the identified UAS in assistance for *educating languages*, *science*, or *process guidance* (cf. Table 1).

Table 1: UAS Assisting in Learning and their Application Domain

Author	UAS	Application Domain
Morana et al. (2015)	ITSM ProcessGuide	Process Guidance Education
Mirzaeian et al. (2016)	Teaching Persian Grammar	Language Education
Amaral et al. (2011)	TAGARELA	Language Education
Heift and Schulze (2003)	German Tutor	Language Education
Sung et al. (2016)	Online Summary Tutor	Science Education
Zhang et al. (2014)	AMT	Science Education
Arnau et al. (2013)	HBPS	Science Education
Kazi et al. (2012)	METEOR	Science Education
Gilbert et al. (2009)	xPST for Paint.NET	Science Education
Leelawong and Biswas (2008)	Betty’s Brain	Science Education
Mitrović (1998)	SQL Tutor	Science Education
Koedinger and Anderson (1998)	PAT	Science Education
Ritter and Koedinger (1996)	Plugin Tutor for Sketchpad	Science Education
Ritter and Koedinger (1996)	Plugin Tutor for Microsoft Excel	Science Education

First, the aspect of *process guidance* is reflected with the “ITSM ProcessGuide”, which supports the understanding of process models and leads to an efficient execution of a process (Morana et al., 2015). The “ITSM ProcessGuide” has a help button, which leads to a more precisely display of a process task. Furthermore, the system displays the actual step of the process, an overview of the complete process, and if necessary additional textual information, links and images. However, the system does not correct the execution of the process step.

Second, language education is the aim of three UAS. This group includes a system that teaches “Persian Grammar” (Mirzaeian et al., 2016). It gives feedback based on the differences in syntax and semantics observed between an Persian and an English text (Mirzaeian et al., 2016). The feedback may be structured as follows: „Sorry, the word <English word> is not the correct equivalent of <Persian word>“ (Mirzaeian et al., 2016).

The correct equivalent is however not proposed. “TAGARELA”, a Portuguese language learning system (Amaral et al., 2011), is able to provide feedback on erroneous inputs and giving hints to use a correctly spelled word. It additionally offers a correct solution by providing a possible answer. For instance, a feedback message may contrast the infinitive of a word used by the student with the infinitival form of the correct word (Amaral et al., 2011). The “German Tutor’s” objective is supporting in learning German (Heift & Schulze, 2003). This UAS gives feedback based on learners’ skill level. The system correlates the detailed output of the linguistic analysis with an error-specific feedback message. Beginners receive explicit feedback for their mistakes, whereas advanced learners only get a hint to correct the mistake. In addition, a summary of the mistakes that a student made during a session can be provided (Heift & Schulze, 2003).

Third, education in *science* is provided by numerous UAS. The “Online Summary Tutor” is an automatic summary assessment and feedback system for summaries written by students in the sixth grade (Sung, Liao, Chang, Chen, & Chang, 2016). It provides score feedback, concept feedback and semantic feedback. „Score feedback provides information about the length of the students' summary (character count), the overall score of the summary, and how well the content of each section of the source text has been covered“ (Sung et al., 2016). Information about the similarity between the scholar‘s summary and the summary of an expert is referred to as semantic feedback. The UAS only provides feedback on what the scholar wrote, but does not hint at what content is missing (Sung et al., 2016). The concept feedback displays a concept map, which was drawn by experts to foster scholar‘s understanding of the conceptual structure of the source text. It provides the whole conceptual structure of the original text no matter what answer was submitted by the scholar. Hence, the systems assists in identifying errors compared to expert knowledge, but does not actively provide hints on what is missing in the students’ summary and on how to overcome errors. The UAS “AMT” is a step-based tutoring system that supports learning a modelling language (Zhang et al., 2014). While using the UAS, students can ask for help in order to get a system-generated hint. For this, the system has a check and give-up button (Zhang et al., 2014). When the check button is used, the UAS gives minimal feedback as it colors entries red if they are incorrect and green if they are correct. When students click the give-up button, the UAS fills in entries correctly, provides correct/incorrect feedback on student's steps and demonstrates steps for students upon request (Zhang et al., 2014). The "Hypergraph Based Problem Solver" (HPBS) teaches an arithmetical and algebraic way of solving problems (Arnau, Arevalillo-Herráez, Puig, & González-Calero, 2013). The UAS gives automatically feedback, if students make a mistake and provides hints if requested (Arnau et al., 2013). To be more specific, HPBS displays feedback when a non-valid input is detected. This feedback uses meaningful semantic messages in a vernacular language. There is immediate feedback for incorrect actions and also help on demand (Arnau et al., 2013). Doing so, the UAS supports the resolution of a problem by following multiple algebraic paths and supports arithmetical resolutions when the structure of relations among the quantities allows it (Arnau et al., 2013). The UAS "METEOR" supports problem-based learning in the domain of medicine (Kazi, Haddawy, & Suebnukarn, 2012). It assesses a student‘s solution and returns hints to guide the student towards a correct solution. To provide students with feedback for partial correct solutions, "METEOR" calculates the closeness of a student‘s solution to a given solution explicitly encoded into the system. Depending on the calculated distance, hints such as "You are very close'' or ''You are quite far off'' are presented to the user. Gilbert, Blessing, and Blankenship (2009) describe an extensible Problem-Specific Tutor (xPST), an open-source architecture for building tutors for existing interfaces, for Paint.NET. It supports students in solving tasks by showing the consequences of mistakes and guiding the user back to the correct method (Gilbert et al., 2009). For this, users have to initiate the tutor in order to get feedback. The system gives just-in-time error messages, if the student takes an incorrect step. Whereas some messages require a student's interaction to dismiss the message, others do not need an interaction to proceed (Gilbert et al., 2009). The system does however, not provide a correct version compared to the student‘s current state, but leaves possible corrections to the student in a learning by teaching manner. "Betty's Brain" is a UAS that teaches middle school science students about river ecosystems (Leelawong & Biswas, 2008). The system allows students to teach a cartoon called Betty using a concept map representation. To evaluate how well Betty has understood the learning content, a set of quizzes created by system designers and classroom teachers is used. When Betty takes the quiz, her answers are graded by Mr. Davis (the mentor) and the results displayed to the user. The mentor can also provide hints to assist users to make corrections in their concept map. To teach Betty in a way that she may answer the quiz questions correctly, users can access online resources, may do a concept map tutorial that provides information on causal structures, and how to reason with these structures, and ask a virtual mentor agent, who provides feedback about learning, teaching, and domain knowledge (Leelawong & Biswas, 2008). The "SQL Tutor" supports learning elements of Structured Query Language (SQL) (Mitrović, 1998). It contains a set of SQL problems and a proposed solutions to these problems. To provide feedback, the system evaluates students' solutions by comparing them to a solution proposed by the UAS. There are five levels of feedback that can be provided by the "SQL-Tutor": positive or negative feedback, error flag, hint, partial solution and complete solution. „At the lowest level (positive/negative feedback), the student is only told whether the solution is correct or not and, in the latter case, how many errors there are (i.e. how many constraints were violated). An error flag message informs the student about the clause in which the error occurred. A hint-type message gives more information about the cause of error. Partial solution feedback displays the correct content of the clause in question, while the complete solution simply displays the correct solution of the current problem" (Mitrović, 1998).The system "PAT" is a cognitive tutor for algebra (Koedinger & Anderson, 1998). "PAT" can provide feedback or hints on any action along the solution path a scholar pursues. The feedback gets stepwise more specific, up to the point where a suggestion for a specific action is provided (Koedinger & Anderson, 1998). The "tool tutor in Sketchpad" assists in teaching geometric construction and the "tool tutor in Microsoft Excel" explains problems with regard to incorrect algebra (Ritter & Koedinger, 1996). In Sketchpad a user receives feedback through a messages window and is instructed to use the „undo" menu to return to a correct solution path. When a user enters an incorrect value in Microsoft Excel, the UAS may change the font in that cell. In cases where a user performed actions, which were disruptive to the solution, users receive a feedback via a message window being instructed to use Excel's „undo“ function to restore an earlier state.

2.5.4.3 Conclusion of Related Work

In our systematic literature review, we considered numerous research outlets in the fields of IS, computer science, human visual perception, and management accounting to identify UAS that aim at supporting learning. Hence, while there might be relevant literature in other outlets, we suppose that our review has a satisfying degree of comprehensiveness to representatively cover prior research in the field of UAS. Having identified 14 different UAS, none of these cover feedback-based learning of BIV guidelines in a work-integrated environment. Hence, we claim to contribute to literature by identifying this research gap and provide first research in this field. In addition, we showed that numerous approaches exist on how feedback might be used to assist in learning. A homogenous conception on how feedback has to be provided by UAS to foster learning is however missing. A theory that ties the aspects of feedback, learning and motivation together is feedback intervention theory (FIT) proposed by Kluger and DeNisi (1996), which is why we use this theory as theoretical background. We will discuss FIT in more detail in the next section.

2.5.5 Designing UAS that aim at Fostering Learning BIV Guidelines

2.5.5.1 Suggesting Design Principles Referring to Feedback Intervention Theory

To characterize how feedback relates to motivation and learning, we refer to FIT introduced by Kluger and DeNisi (1996). FIT is a well-documented psychological framework (Hysong et al., 2012), which comprises knowledge from various theories (e.g., action identification theory or goal setting theory). Referring to action identification theory (Vallacher & Wegner, 1987), FIT posits that feedback provides new information to the feedback recipients, which redirect the recipients' locus of attention among three hierarchically organized levels of control. Feedback provides information that may either lead to learning, motivation, or reflection about oneself. Since feedback highly influences task learning processes and task motivation processes (Kluger & DeNisi, 1996), we focus on these two aspects in this study. For learning and motivation processes, the characteristics of feedback cues play a key role. They determine whether the motivational aspect or learning aspect is influenced. Therefore, in the next step, we deduce design principles for feedback that aims at either learning or motivate to learn, whereat we refer to learning as the activity of closing the gap between a learner's present knowledge state and the state implied by the learning aim (Sadler, 1989).

First, we discuss design principles that may directly affect learning. When people are confronted with new or complex tasks (e.g., creating business charts, which comply with the IBCS), acquiring task knowledge and skills may be necessary to be successful. This can be achieved with corrective feedback (i.e., feedback that contains a correct solution), which directly induces learning referring to FIT (Kluger & DeNisi, 1996). Hence, we deduce "*providing corrective feedback*" as our first design principle. UAS may influence learning when they provide feedback on how to achieve a correct solution. In a BIV context, this may be achieved when a UAS shows chart objects that cause a violation (e.g., a truncated axis) and explains aspects that have to be corrected, using a specific guideline (e.g., IBCS guidelines) that refers to this violation.

Second, we discuss design principles aiming at motivation to learn. Although, corrective feedback directly induces learning processes, the origin for learning is often on the motivational level (Kluger & DeNisi, 1996). Hence, aspects of motivation have to be considered in our study. Velocity feedback (e.g., directing attention to past performance levels) for example, affects motivation processes. For these motivation processes, FIT refers to the goal setting theory introduced by Latham and Locke (1991). Goal setting theory implies that difficult and specific goals lead to a higher level of task performance than do easy and abstract goals (Locke & Latham, 2006). This is however valid only, as long as a person is committed to the goal and has the requisite ability (i.e., task knowledge and skills) to attain it (Locke & Latham, 2006).

The task to comply with BIV guidelines can be regarded difficult, since studies indicate that assistance and learning opportunities are needed to cope with this task (Kohlhammer, 2014; Riedner & Janoschek, 2014). The abstract goal to comply with a set of guidelines (e.g., the IBCS guidelines) may be common in organizations. For instance, in a BIV context, companies strive to introduce compliance standards (Bange et al., 2017; Gluchowski, 2014). Using UAS may help to specify this overall goal in a specific situation, which is for example when a report creator designs a new or redesigns a given business chart. Hence, we deduce "*providing a specific goal*" as our second design principle. For example, UAS may display a correct solution of a business chart alongside the incorrect status of this business chart. In addition, UAS may show the report designer, how often the current state of the business chart infringes a given set of guidelines (e.g., the IBCS guidelines). To succeed in complying with the guidelines, the goal is to eliminate the incorrect aspects of the business chart and match the displayed target state. Hence, a specific goal is provided.

Moreover, UAS should affect a person's goal commitment (i.e., the degree to which the individual is attached to the goal and is determined to reach it (Latham & Locke, 1991)). According to Latham and Locke (1991), goal commitment can be enhanced, when a person believes that achieving a goal is possible, which raises the person's expectancy of success. Training and information of past performance can positively influence this (Latham & Locke, 1991). Therefore, we deduce "*providing training possibilities*" as third design principle and "*providing information about past performance*" as fourth design principle for UAS. A UAS that provides training possibilities (e.g., the possibility to apply directions on how to correct a business chart) and information about past success (e.g., a history of attempts and corresponding error rate) may influence goal commitment and hence motivation.

In summary, we deduce four design principles that may be taken into account when designing UAS that aim at supporting learning. These are providing corrective feedback, a specific goal, training possibilities, and information about past performance.

2.5.5.2 Instantiating the Design Principles: The BIV Learning Assistant

2.5.5.2.1 Technological Background and Scope of the Artifact

Our UAS, the "BIV Learning Assistant", is a Microsoft Excel based Add In developed via Visual Basic for Applications. Microsoft Excel is used since according to Deloitte (2012) 89% of participants among 910 companies responded that they use spreadsheet applications (e.g. Microsoft Excel) for analyzing and structuring financial data. The BIV Learning Assistant can detect infringements of eight IBCS guidelines. These are: avoid colored or filled backgrounds, avoid borders, shades, and pseudo-3D, avoid decorative colors, replace grid lines and value axes with data labels, unify time periods and points of time, replace pie and ring charts, avoid truncated axes, and avoid logarithmic axes (Hichert & Faisst, 2017). With regard to chart types that can be analyzed, we focus on column- and bar charts, pie charts and line charts since these account for approximately 95% of all visualizations in annual reports of companies, which are listed on the German stock exchange DAX 30 (Eisl et al., 2015).

2.5.5.2.2 Design of the Artifact

Referring to the theoretical background, the BIV Learning Assistant provides instantiated design principles for corrective feedback, specific goals, training opportunities, and information about past performance in order to foster learning BIV guidelines (see Figure 1).

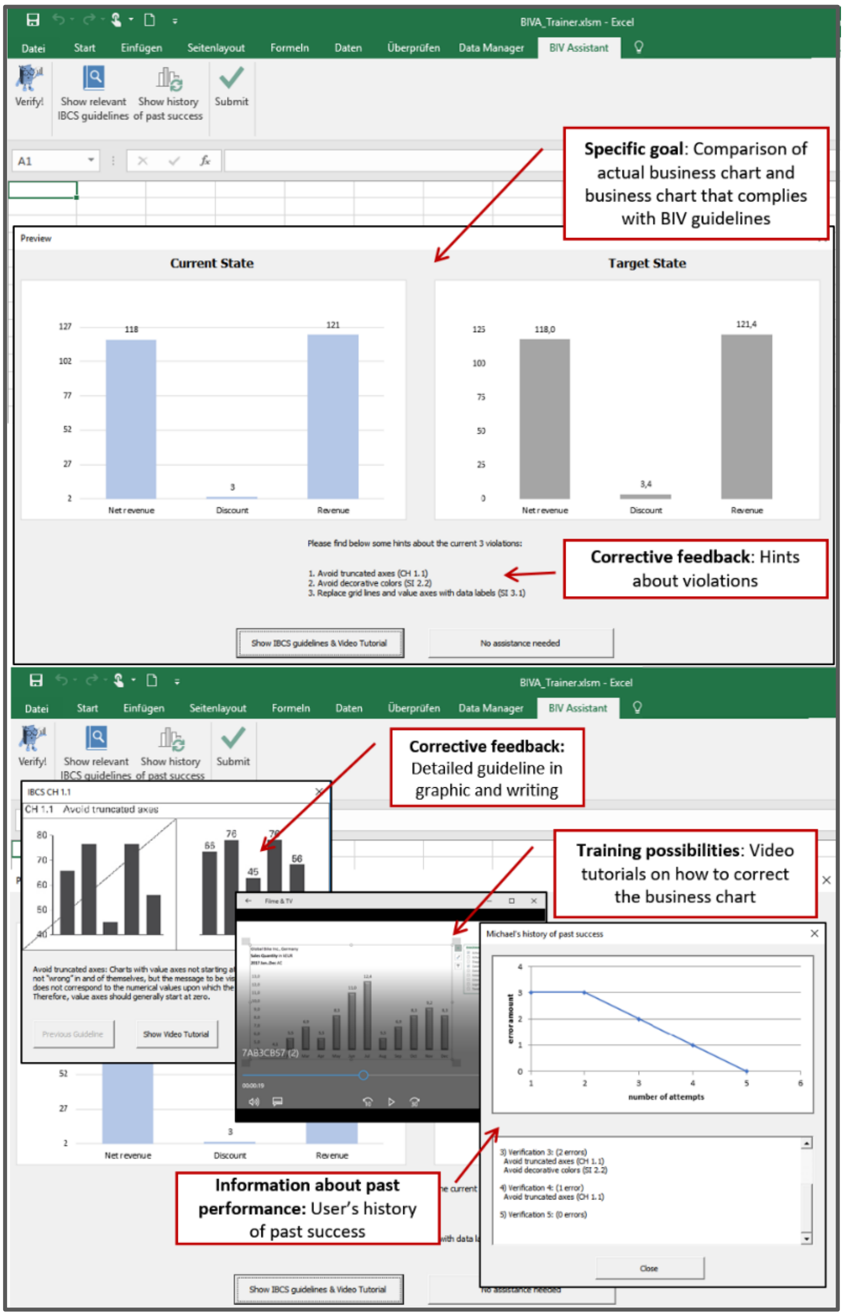

Figure 1: BIV Learning Assistant - Screenshots of Instantiated Design Principles

2.5.5.2.2.1 Corrective Feedback

Since feedback cues are most useful when they provide direction for searching (Hattie & Timperley, 2007), the BIV Learning Assistant shows hints, which direct to inappropriately designed chart objects. For example: "Do you think a truncated axis provides a visually appropriate basis for decision making?" At this stage, based on the current information, a report designer can decide whether to correct the actual business chart or to request further assistance. In case of further assistance, the BIV Learning Assistant provides more detailed information referring to these chart objects on request. Doing so, the BIV Learning Assistant cites IBCS guidelines that are violated in the current business chart and explains why report designers should comply with these guidelines. Referring to truncated axes, the following message according to the IBCS guideline CH1.1 will be shown: "Charts with value axes not starting at zero ("cut" axes) are not "wrong" in and of themselves, but the message to be visually conveyed then does not correspond to the numerical values upon which the chart is based. Therefore, value axes should generally start at zero" (Hichert & Faisst, 2017). An image provided by the IBCS Institute for every guideline complements the textual message. With this design aspect, we aim to directly influence learning while we intend to influence motivation to learn with the remaining design elements outlined in sections 2.5.5.2.2.2 to 2.5.5.2.2.4.

2.5.5.2.2.2 Specific Goals

Since studies demonstrate that effective feedback should provide cues (Hattie & Timperley, 2007), the BIV Learning Assistant's feedback message contains in a first step the number of incorrect objects to specify the number of violations. Next, the BIV Learning Assistant displays the current version of the business chart alongside a corrected version of the same business chart to provide a means of comparison and hence a specific goal that has to be reached by the report designer. Since textual descriptions of a visual object may have some limitations in terms of comprehension (Kuechler & Vaishnavi, 2006), we chose to use an image to specify the goal.

2.5.5.2.2.3 Training Opportunities

Whenever there is the need to verify a designed report and learn about how to comply with the IBCS guidelines with regard to a specific report, the BIV Learning Assistant can be activated. Training opportunities are provided, since the report designer can decide at every feedback step to self-reliantly amend the current status of the business chart or to request further feedback. After each attempt of correcting the business chart, the report designer can have the BIV Learning Assistant to verify the amended business chart and to provide feedback based on the new status. As video-assisted instructions are an effective form of feedback (Hattie & Timperley, 2007), the report designer can opt to watch a brief video tutorial on how to amend the business chart to comply with violated IBCS guidelines. In summary, the BIV Learning Assistant provides non-guided as well as guided training possibilities.

2.5.5.2.2.4 Information about Past Performance

Every time the report designer asks the BIV Learning Assistant to verify the current status of the business chart, data about the status of the business chart is collected. Hence, upon request, the BIV Learning Assistant can provide information about the past performance. This performance information comprises the number of attempts to correct the business chart including the number of incorrect elements in both, visual and textual manner. We specifically focused on performance information that relates to the report designer's own performance solely, since comparisons to other persons or grades as performance indicators may impede learning (Kluger & DeNisi, 1996).

2.5.5.2.3 Functionality and Architecture of the Artifact

As proposed by Peffers et al. (2007), we introduce the artifact's desired functionality and its architecture. UAS should reduce a users' mental working memory and not additionally burden the user with interruptions at the wrong time (Gregor & Benbasat, 1999). Hence, we chose a user-triggered invocation to activate the BIV Learning Assistant. After activation, the assistant starts to screen a selected business chart for inappropriately visualized elements. In case there are such elements, the report designer gets a feedback message. For this, the module ActivationManager (cf. Figure 1) activates the different user interface elements of the BIV Learning Assistant with the function getEnabled(). It also activates the welcome screen, where the user logs in with the login() function. With the function verify() the user can check business reports for visualization mistakes. For this, the chart's features such as chart type or scaling is passed from the Excel Workbook to the module AnalysisManager with the function inspectChart(). With the help of the module CheckManager the chart will be screened for errors. The results of this screening will then be sent back to the AnalysisManager and from there to the modules HintManager, TextManager and HistoryManager.

Next, the BIV Learning Assistant displays the current version of the business chart alongside a corrected version of the same business chart to enable a comparison and hence presents a specific goal to the report designer. This is achieved by the module HintManager that calls the function showHint() to display a window with the chart in its current state next to its IBCS compliant target state, which is created by using the alterChart() function. Underneath, the graphical comparison, specific hints are given on how to improve the visualization. Activating the function playVideo() displays a video that instructs the user on how to correct the errors of the business chart.

The HistoryManager saves the amount of errors user made on each verification. With the help of a graph, the number of errors for each try are displayed. This may show the user's performance improvement over time.

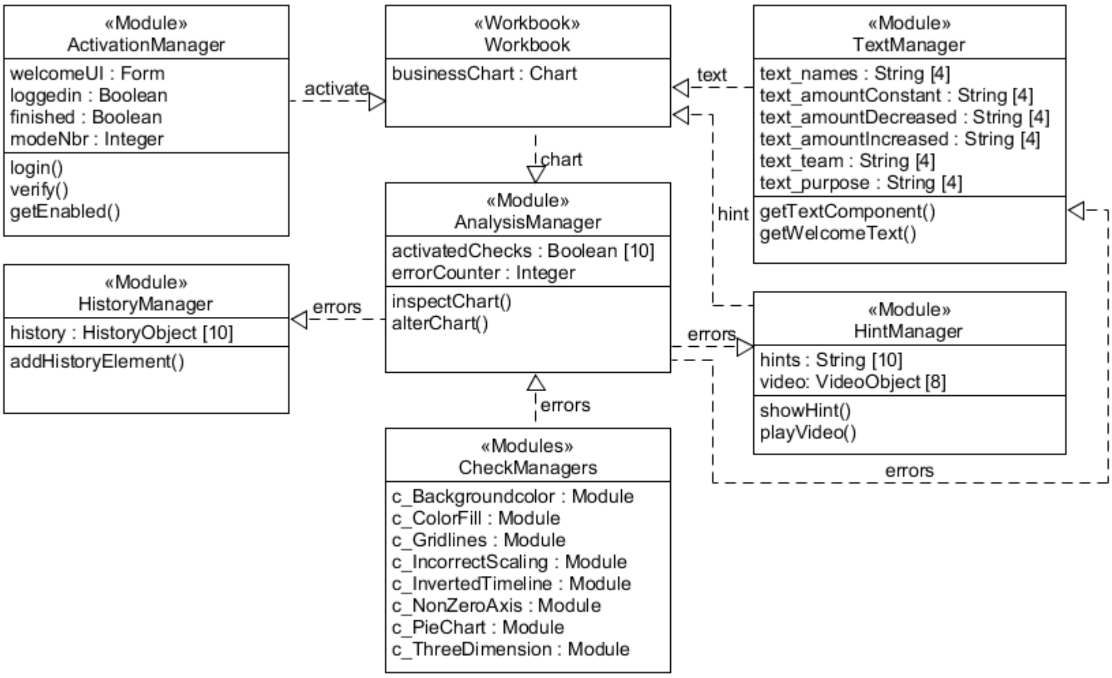

Figure 1: Architecture of the BIV Learning Assistant

2.5.6 Evaluation of the Artifact

2.5.6.1 Hypotheses

A typical training situation may be that companies provide written learning materials on a specific topic with which employees have to train themselves autonomously. This concept of learning may be supported by literature that views written learning materials (e.g., books) as an agent that can provide feedback (Hattie & Timperley, 2007). In our case, such learning situation can be described by providing report designers with a written documentation of BIV guidelines (i.e., IBCS guidelines) in order to learn such BIV guidelines and hence, being aware of inadequately visualized elements in business reports. Although, this approach may be common, we believe that UAS providing feedback will lead to better learning outcomes than written training material. In particular, we believe that the BIV Learning Assistant, which was designed according to design principles deduced from FIT, will help report designers to gain superior learning outcomes compared to report designers, who are provided with a printed version of IBCS guidelines. Therefore, the first hypothesis (H) of this study is:

H1a: Participants, who use the BIV Learning Assistant for learning BIV guidelines have higher learning outcomes than those who use a printed documentation of BIV guidelines.

Since, business reports often lack appropriate visualizations, companies may use software that supports in complying with BIV guidelines. Examples are Chart-me XLS by Gerths (2018), which provides IBCS conform templates or the BIV Assistant, which automatically corrects inadequately visualized chart elements upon user request (Schelkle, 2017). Although these software are originally installed to comply with BIV guidelines, companies may tend to utilize them for learning purposes in the belief that providing BIV compliant business charts will be sufficient to learn such guidelines. This may be true, as those systems provide feedback by amending business charts to comply with predefined BIV guidelines. Although this view might be valid to some extent, we believe that such assistance in learning is not as effective as the learning support provided by the BIV Learning Assistant. We therefore hypothesize:

H1b: Participants, who use the BIV Learning Assistant for learning BIV guidelines have higher learning outcomes than those who use software that automatically amends business charts to comply with such guidelines.

These hypotheses are predicted as a consequence of the feedback-based learning support, which takes design principles deduced from FIT into account: corrective feedback, specific goals, training opportunities, and information about past performance. Besides these group comparisons, we are also interested in the efficacy of the means of learning assistance. We expect report designers that use the BIV Learning Assistant will increase their BIV knowledge significantly better compared to the other two aforementioned discussed means of learning assistance. Therefore:

H2: Participants, who use the BIV Learning Assistant as means of learning assistance will experience a significant increase of BIV knowledge, whereas those who use software that aims at assisting in complying with BIV guidelines or those who use written documents won't experience a significant increase of BIV knowledge.

2.5.6.2 Evaluation Design and Participants

According to Peffers et al. (2007), key in DSR projects is to measure how well an artifact supports a solution to the problem by comparing the objectives of a solution to actual observed results from use of the artifact. Since an artificial evaluation environment has the advantage of controlling for possibly confounding factors and since our artifact has already been developed ("ex post evaluation"), we decided to conduct a laboratory experiment using a between-subject design (cf. Table 2), as suggested by Venable et al. (2012). Participants were recruited at a German University and have been randomly assigned to one of three groups by a lottery procedure (cf. Table 3).

Table 2: Experimental Design of the Evaluation

Group (N)	Pretest	Treatment	Qualitative Questions	Posttest
A (13) B (11) C (14)	BIV knowledge	BIV Learning Assistant BIV Compliance Assistant Written IBCS guidelines	Design aspects with regard to directly foster learning. Design aspects with regard to motivate learning.	BIV knowledge

To evaluate the participants’ BIV knowledge, they had to identify inadequately designed visual elements (e.g., truncated axes or pseudo 3D-effects) in five differently flawed business charts. We used these flawed reports for both pre- and posttest, however changed the sequential order of the reports for the posttest to account for replication errors. During the treatment phase, all participants had to fulfill the same task. We provided eight different business charts that each suffered from inadequate BIV referring to those IBCS guidelines and chart types implemented in the BIV Learning Assistant. Participants had to identify and correct the errors of these predesigned business charts. Although the task was same for all participants, the means of learning assistance (i.e., treatment) differed. Group A was equipped with the BIV Learning Assistant, group B with the BIV Compliance Assistant (Schelkle, 2017), and group C with an official printout of the IBCS guidelines. Having finished the treatment phase, all participants had to fill in a questionnaire with open questions regarding design aspects of the artifact. After 4 days participants were asked to do the posttest. If a participant did not identify a BIV error in the pretest but managed to do so in the posttest, we considered this an observed learning outcome.

Table 3: Demographics

		Group 1	**Group 2**	**Group 3**	**Total**
Gender	Male	7 (46%)	4 (36%)	9 (64%)	20 (47%)
	Female	6 (54%)	7 (64%)	5 (36%)	18 (53%)
	Total	13 (100%)	11 (100%)	14 (100%)	38 (100%)
Age	min/ max	20/ 26	21/ 28	20/ 25	20/ 28
	Average	22,5	23,2	22,5	22,7

2.5.6.3 Evaluation Results

2.5.6.3.1 Results on Learning Outcomes

We used SPSS version 25 to analyze differences in learning outcomes. To evaluate the learning outcomes between our three experimental groups, we introduced the Learning Target Achievement Factor (LTAF), which we refer to as the fraction of correctly identified BIV errors and the maximum possible number of BIV errors to be identified, based on the results of the posttest. The LTAF can range between zero and one. A score of zero is achieved when none of the BIV errors incorporated in the business cases are identified, a score of one when all errors are detected. Since we are interested in group differences, we conducted a one-way ANOVA with planned contrasts to assess the effects of feedback-based assistance on learning outcomes (as measured by LTAF) to test hypotheses 1a and 1b. Regarding the requirements for this analysis method, we first checked whether the data is normally distributed. Again, feedback-based assistance was distinguished into one of three groups. Group A: BIV Learning Assistance ($M = 0.66$, $SD = 0.21$), group B: BIV Compliance Assistant (M=.45, SD=0.16), and group C: Printed IBCS Guidelines (M=.35, SD=0.22). The result of Shapiro-Wilk test demonstrates that the data for all groups is normally distributed (Shapiro-Wilk test, p>.05). Next, there were no major outliers, according to inspection with a box-plot. Homogeneity of variances was asserted using Levene’s Test which showed that equal variances could be assumed (p=.676). Finally, the results of the one-way ANOVA demonstrated that the level of learning outcomes differed statistically significant for the differently treated groups, demonstrating high effect size according to Cohen (1988), $F(2, 35) = 8.55$, p=.001, $\eta^2 = .33$. This result, being interpreted that at least two of the groups distinguish significantly with regard to learning outcomes, does not indicate which group performs significantly better in terms of learning outcomes compared to the other groups. Hence, we calculated planned contrasts in a next step to compare the groups. The results show that there was a statistically significant difference in LTAF-scores of -.21 (SE=0.08), *p*=.014 between the groups A (BIV Learning Assistant) (*M*=0.66, *SD*=0.21) and B (BIV Compliance Assistant) (*M*=.45, *SD*=0.16). This, being interpreted that group A has significantly higher learning outcomes than group B. Moreover, groups A (BIV Learning Assistant) (*M*=0.66, *SD*=0.21) and C (printed IBCS guidelines) (*M*=.35, *SD*=0.22) also showed a significant difference in LTAF–scores, -.32 (SE=0.08), *p*<.001. This again demonstrates that learning outcomes of group A are significantly higher compared to group C. The comparison of groups B and C complements the analysis. The result does not indicate significant differences in LTAF-scores, -.10 (SE=0.08), *p*=.214): group B (BIV Compliance Assistant) (*M*=.45, *SD*=0.16 and C (printed IBCS guidelines) (*M*=.35, *SD*=0.22). In summary, we claim that hypotheses 1a as well as 1b can be supported based on our analysis. Participants, who use the BIV Learning Assistant for learning BIV guidelines have significantly higher learning outcomes than those groups using software that aims at assisting in complying with such guidelines or use a printout of BIV guidelines.

For assessing possible increases in BIV knowledge, pre- and posttests were conducted. Again, if a participant did not identify a BIV error in the pretest but managed to do so in the posttest, we considered this an observed increase in BIV knowledge. Since this kind of comparison is essentially a within-subject analysis, we used dependent t-tests to observe increases in BIV knowledge for each group. The results of the dependent t-test (cf. Table 4) illustrate that the means of group A, being treated with the BIV Learning Assistant, increased highly significant at the *p*<.001 level after using the BIV Learning Assistant as means of learning, *t*(12) = +7.908, *p*<.001.

Table 4: Results of the dependent t-test

Group	N	M_{PRE}	M_{POST}	ΔM
A (BIV Learning Assistant)	13	.32	.67	**.34*** **
B (BIV Compliance Assistant)	11	.34	.45	**.11**
C (Printed IBCS – Control Group)	14	.31	.35	**.04**

* significant at the p<.05 level
** highly significant at the p<.01 level
*** highly significant at the p<.001 level

Having recognized on average 32% of incorrectly visualized elements in the pre-test, participants were able to identify 67% of inadequately visualized elements after using the BIV Learning Assistant. The average of all identified BIV errors in the pre-test was 34% and increased to 45% in the posttest for participants making use of the BIV Compliance Assistant (group B). Although, the means of group B increased by 0.11 percentage points after using the BIV Compliance Assistant as means of learning, this increase was non-significant, $t(10) = +1.982$, $p=.076$. The control group (group C) performed slightly worse to group B. The results show that attendees of this group identified on average 35% of the errors embodied in the business cases in the posttest, whereas the pre-test showed that participants recognized only 31%. While the means of the control group increased slightly after using a printout of the IBCS guidelines as means of learning, this increase is not significant, $t(13) = +1.013$, $p=.330$. Hence, we summarize that BIV knowledge of all participants is on a comparable level at the beginning of the experiment, which can be deduced from the means of the pre-test ranging from 31% to 34% of identified BIV errors. Although, being on the same level at the beginning of the experiment, after the treatment each group showed significant differences with regard to learning outcomes. Based on the results of the dependent t-test, we were able to show that only the BIV Learning Assistant increases BIV knowledge highly significantly ($p<0.001$). Although the means of the groups that used the other described assistances increased moderately, this improvement was non-significant. Therefore, we claim that hypothesis 2 can be supported: the BIV Learning Assistant shows superior results for increasing BIV knowledge compared to the other tested means of learning assistance.

2.5.6.3.2 Results on Design Aspects

To study if our instantiated design principles are perceived to affect learning or motivation and to analyze if there are further design elements to be considered to foster learning or motivation, we conducted a summative qualitative content analysis (Hsieh & Shannon, 2005). For this, we analyzed participants' comments on the following open questions.

With regard to the provided means of assistance, what exactly (1) do you consider as being beneficial/ obstructive for learning BIV guidelines (cf. Table 5), and (2) do you consider as being motivating/ demotivating to learn BIV guidelines (cf. Table 6)? Since merely the BIV Learning Assistant resulted in significant learning outcomes, we focus on group A's comments in this study.

Table 5: Comments on Design Aspects with Regard to Fostering Learning

Participants regarded beneficial	**#**	**Participants regarded obstructive**	**#**
Self-explanatory illustration through videos	6	Need to change between edit- and dialog window	5
Feedback	3	English language	1
Training possibility	2	Not detailed enough instructions on how to use the software	1
		Provided solution approach is short on detail	1

Examining comments on design aspects specifically related to foster learning (cf. Table 5), participants considered video instructions most beneficial. Receiving feedback was ranked the second most important design aspect. This confirms to some extent that our supposed design principle "corrective feedback" may directly result in learning outcomes. However, the comments were not detailed enough to explicate whether participants meant corrective feedback cues or other types of feedback. Last, remarks on training possibilities were also mentioned to be beneficial to foster learning. These results are somewhat surprising, since according to FIT, most of the discussed design elements ought to increase motivation to learn, rather than directly learning. An important design feature participants wished for, is to have the possibility to edit business charts while receiving feedback and thus not being forced to change between the edit- and dialog window. Considering this aspect might reduce clicks and thus further increase ease of using the artifact. To complement the analyzed comments, some scattered notes were related to more personalization, better support functionalities on how to use the artifact and more detailed instructions on how to correct flawed business charts. Since, each of these elements were only stated once, we regard them as being of minor relevance.

Table 6: Comments on Design Aspects with Regard to Motivate or Demotivate Learning

Participants regarded motivating	**#**	**Participants regarded demotivating**	**#**
Fast learning success	5	Use of grey color	1
Feedback on mistakes	4	Working with the tool and editing the diagram is not possible in parallel	1
Tracking of errors motivates to be successful	1	Not enough detailed instructions on how to correct the chart	1
Playful learning of the expertise	1		

The next set of comments relates to design aspects that are perceived to either motivate or demotivate learning. Participants mentioned most often perceived fast learning success as being motivating. Although, this may not be considered as design feature, it confirms that participants felt that the BIV Learning Assistant successfully supports learning. Such as aforementioned discussed, participants regarded feedback on mistakes as highly important design feature. Moreover, tracking one's own errors and playful learning, which we interpret as feedback about past performance and training possibilities, were sparsely mentioned as being motivating. Only few comments, such as use of grey color for the artifact were made about aspects being demotivating. The demotivating feature "working with the tool and editing the diagram is not possible in parallel" was again assessed as unfavorable.

Based on our summative qualitative content analysis, we conclude that all instantiated design principles of the BIV Learning Assistant are either perceived as being directly supportive for learning or being motivating to learn. Since some design aspects are mentioned in both categories, we can however hardly distinguish design aspects for being directly supportive for learning or being motivating to learn. An important feature participants wished for is to have the possibility to use the UAS and edit the business chart in parallel.

2.5.7 Discussion and Conclusion

Overall, the evaluation results are promising and the findings described constitute novel und useful contributions in IS on how learning can be supported with feedback-based UAS. To discuss this paper's contributions in more detail, we refer to modes of inquiry customary to DSR introduced by Briggs and Schwabe (2011).

The first mode of inquiry applied in this study is exploratory research, which reports for example challenges in user environments or describes newly discovered aspects (Briggs & Schwabe, 2011). Our systematic literature review demonstrates that several methods exist on how feedback may be used by UAS to support learning. There is however, no common agreement in the field of UAS on how feedback may be applied for this purpose. Next, we show that none of the identified UAS cover feedback-based learning of BIV guidelines in a work-integrated environment. A limitation to be mentioned though, is the restricted search space. Even so, we considered numerous research in the fields of IS, computer science, human visual perception, and management accounting, there still might be relevant literature in other outlets. However, our literature does not necessarily need to be exhaustive for its main contribution, since our aim was to representatively cover prior research in the field of UAS. For this purpose, we suppose that our review has a satisfying degree of comprehensiveness.

The second mode of inquiry we refer to is applied research and engineering, which leads to instances of generalizable solutions, proof-of-concept prototypes, and evidence that solutions are useful and generalizable (Briggs & Schwabe, 2011). In our case, we developed the first UAS that fosters feedback-based learning of BIV guidelines. We describe its design and functionality and provide its architecture, which may be used for further research within the field of BIV, but also in the field of UAS in general. The usefulness of our artifact was demonstrated via a laboratory experiment. Thus, we contribute a novel and useful artifact to the domain of UAS. An important limitation to be discussed is that the current version of the artifact merely incorporates eight BIV guidelines and is developed as Microsoft Excel Add In. Even so, Microsoft Excel may currently still be used for business reporting in various organizations, more sophisticated BI software is advancing (Gräf et al., 2013). However, this amply demonstrates the importance to provide evaluated, generalizable findings based on instantiated artifacts to lay the foundation for future research. For example, more BIV guidelines can be included in a future version of the artifact or researchers may build on this study's contributions to develop new artifacts for more sophisticated BI software.

The last mode of inquiry employed is experimental research. This mode of inquiry leads to hypotheses, experimental designs, and analyzed data sets (Briggs & Schwabe, 2011). We deduced hypotheses referring to FIT, which was used to design our artifact. These hypotheses comprised between group comparisons as well as within-subject comparisons to evaluate the artifact's efficacy. We decided to conduct a laboratory experiment using a between-subject design to control possibly confounding effects and since our artifact has already been developed (Venable et al., 2012). The results of a one-way ANOVA with planned contrasts show that participants using the BIV Learning Assistant for learning BIV guidelines have significantly higher learning outcomes than those groups using software that aims at assisting in complying with BIV guidelines or use a printout of such guidelines. Further, dependent t-tests demonstrate that increases of BIV knowledge are highly significant only when the BIV Learning Assistant is applied. Limitations may be the relatively small number of participants. The requirements to conduct a one-way ANOVA have however been successfully tested. Shapiro-Wilk test demonstrates that the data for all groups is normally distributed (Shapiro-Wilk test, $p>.05$), Levene's Test proves homogeneity of variances ($p>.05$). Last, we conducted a qualitative summative content analyses. The findings indicate that all instantiated design principles of the BIV Learning Assistant may be helpful for learning or for being motivating to learn. An important design aspect, which we did not consider is the possibility to use the UAS and edit a business chart in parallel. Moreover, some of the analyzed comments make it hardly possible to conclude whether design aspects specifically address either motivation or learning. Therefore, future research may analyze this aspect in more detail.

In summary, we introduce a new and verified useful artifact, with which we contribute to gaining insight on how to personalize real-time instruction and training in business contexts – a grand challenge in the field of IS research (Mertens & Barbian, 2015). Finally, we support decision makers by providing reports that may achieve their central task: showing relevant information and creating business transparency due to appropriately visualized chart elements.

2.6 Essay: Developing a Serious Game for Business Information Visualization

Authors:	Christian Karl Grund Michael Schelkle Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg christian.grund@wiwi.uni-augsburg.de michael.schelkle@wiwi.uni-augsburg.de
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2.6.1 Abstract

Business information visualization (BIV) is increasingly recognized by companies as being essential to avoid threats and realize opportunities. However, many companies still do not seem to know how to improve their BIV. Serious games appear to be a promising approach to convey this knowledge. To investigate the question whether using serious games to improve BIV skills is beneficial, they should be empirically evaluated. However, we could not identify such games in our literature review. The main goal of this study is therefore to fill this gap by contributing a serious game that aims to improve players' BIV skills. Within the game, players compete across several minigames that each address one specific guideline for achieving adequate BIV. A software prototype of the game is developed using the human-centred design process. After its development will have finished, areas of application and evaluation will include education as well as employee training in companies.

2.6.2 Introduction

Business information visualization (BIV) is increasingly recognized by companies as being essential to avoid threats and realize opportunities (Evelson & Yuhanna, 2012). By effectively using BIV, companies may reduce wrong decisions caused by incomprehensible or misleading data (Ware, 2012). For instance, the accident of the space shuttle Challenger may have been avoided using more appropriate information visualization (Tufte, 1997). However, many companies still do not strive for adequate BIV in their management reporting (Al-Kassab et al., 2014). A possible explanation for this is the lack of knowledge about proper visualization practices (Few, 2012). Since serious games already foster cognitive learning outcomes in many domains (Connolly et al., 2012; Wouters et al., 2009), they appear to be a promising approach to convey this knowledge. The overarching research question of our project is therefore whether it is beneficial to use serious games that improve players' BIV skills, especially compared to more traditional learning methods (e.g., lectures). To investigate this question, serious games that focus on BIV should be empirically evaluated. However, this evaluation would require that these games have already been developed. Since we could not identify such games in literature, this study sets out to fill this gap first by introducing a serious game that aims to improve players' BIV skills. Hence, the research objective of this study is as follows:

Develop a serious game that improves players' business information visualization skills.

This study conforms to design science research (Hevner et al., 2004) and presents a software prototype as its artifact that emerged from the first iteration of the human-centred design process (ISO, 2010). In the following, we will outline the theoretical background and related work as well as the development method. After describing the resulting prototype, the paper closes with a discussion, conclusion, and next steps.

2.6.3 Theoretical Background

Information visualization is defined as “the use of computer-supported, interactive visual representations of abstract data to amplify cognition” (Card et al., 1999). When information visualization technologies are used to visualize business data or information (e.g., with tables or column charts) it is referred to as BIV (Tegarden, 1999). A possible approach to improve BIV skills is the use of visualization guidelines that support design decisions and draw on insights from cognitive psychology such as gestalt theory (Ware, 2012). Although several guidelines for information visualization exist (e.g., Shneiderman, 1996; Tufte, 1997; Ware, 2012), only few focus on elements used specifically in business reports. One framework that highlights the design of business reports and presentations are the International Business Communication Standards (IBCS) (Hichert & Faisst, 2015). This framework comprises specific guidelines that showcase bad examples of BIV alongside their proposed corrections. We will hence incorporate these guidelines in our serious game to enable players to identify inadequate BIV and to suggest reasonable improvements. These two skills, namely being able to identify inadequate BIV and being able to suggest reasonable improvements, are what we refer to as BIV skills in this study. To acquire them, an understanding of the interactions between symbols, shape effects, colors, etc. (Ware, 2012) is required which is supposed to be fostered by the guidelines used in our serious game.

In contrast to gamification, where game elements are used in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011), serious games constitute whole games that are not limited to the purpose of entertainment but also focus on improving skills and teaching players educational content (Abt, 1987). Since these games aim to improve learning through intrinsic motivation, their theoretical background includes several learning and motivation theories like self-determination theory and flow theory (Grund, 2015).

One specific theory used to describe player motivation in serious games is tournament theory (Liu, Li, & Santhanam, 2013). It assumes that competition between equally skilled players increases effort, enjoyment and arousal while playing. Hence, competition will be a central aspect of the serious game developed in this study.

2.6.4 Related Work

Prior to developing a serious game for improving BIV skills, we want to characterize the state of the art of BIV as a learning goal or a learning outcome in serious games. Susi, Johannesson, and Backlund (2007) provide a basic overview of serious games, referring to Michael and Chen (2006) who claim that communication skills (i.e., effectively presenting ideas when speaking, writing, etc.) are important for employees in corporations. Although this might include BIV, this learning goal is not explicitly stated. Connolly et al. (2012) investigate empirical evidence on the learning outcomes of computer games and serious games in a systematic literature review. Out of the 129 publications they identified, 17 higher quality studies report knowledge acquisition and content understanding outcomes. However, none of these studies mention BIV as a learning outcome. Another literature review about the learning outcomes of serious games conducted by Wouters et al. (2009) concludes that cognitive learning outcomes (i.e., knowledge and cognitive skills) can be observed in 12 out of the 28 empirical studies investigated. Although they argue that serious games seem to be effective when it comes to cognitive learning outcomes, BIV was again not a learning goal in any of the studies. In a recent literature review about using serious games to improve the decision process, Grund and Meier (2016) show that BIV is not addressed in their sample of serious games that include business reporting. In summary, according to the investigations mentioned above, a serious game that specifically focuses on improving BIV skills seems to be still missing. We intend to fill this gap with the serious game described in the following sections.

2.6.5 Development Method

Several approaches for developing serious games have been proposed thus far (e.g., de Freitas & Jarvis, 2006; Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, & Fernández-Manjón, 2008; Nadolski et al., 2008). Although there does not seem to be an established standard or a thorough evaluation among these development processes, they all concur that for a serious game to be successful, both educational objectives as well as providing an entertaining experience are important. Since the latter can only be evaluated through actual playing, a development process should encompass several iterations of play-testing with prospective users. For this reason, we suggest to employ the human-centred design process specified by ISO (2010) that is prevalent in the domain of human computer interaction (Earthy et al., 2001).

Before going through the design steps of the human-centred design process, the basic structure of the serious game has to be planned. We intend to develop a 2-dimensional game that addresses guidelines for adequate BIV in a competition between players. This competition consists of several minigames that each address one specific guideline. To emphasize the sense of competition, every minigame is loosely based on Olympic sports, hence the name "Dashboard Olympics".

As a first design step, the context of use needs to be understood and specified. In our case, the target group consists of university students in a management information systems course about business reporting (i.e., prospective BIV professionals and junior managers). The course already features a tutorial on reporting software in the first week that is delivered in a computer room containing 30 workstations in the same network. Hence, this setting will serve as the context of use for the Dashboard Olympics.

Next, we will specify the user requirements. Users include the organization (i.e., university) as well as the players (i.e., students). From an organizational perspective, it is important that players understand the learning content (i.e., how to improve BIV). From a player perspective, an entertaining experience (e.g., having fun, feeling immersed, etc.) is desirable.

The production of design solutions is twofold: First, guidelines from the IBCS are matched with several game mechanics in a brainstorming session to draft minigames for the Dashboard Olympics. This form of ideation leaves room for creativity while still focusing on the learning content. Second, the drafted minigames are implemented as a software prototype using the Unity game engine.

To evaluate the game against requirements, we conduct semi-structured interviews with play-testers. Interview questions include items from the game experience questionnaire (IJsselsteijn, de Kort, & Poels, 2008) that cover player requirements. Additional questions aim to assess the understanding of different ways to improve BIV, which addresses organizational requirements. Last, there is space for play-testers to add individual thoughts and suggest improvements.

2.6.6 Software Prototype

The following software prototype resulted from the first iteration of the human-centred design process described above. It comprises four minigames (i.e., Olympic sports) that each address one specific guideline for adequate BIV from different perceptual IBCS rule sets (i.e., condense, check, express, and simplify) which are for instance based on gestalt theory (Hichert & Faisst, 2015). Since tournament theory suggests that only equally skilled players should compete, the interactions in each minigame are very simple so that for example prior experience with video games is negligible. Players can score between 0 and 100 points per minigame that are displayed in a global leaderboard after finishing. These points serve as a mechanic for achieving motivation, they do not indicate learning success. The game ends when every minigame is finished and the overall winners (i.e., first, second, and third place) are announced. As proposed by Garris et al. (2002), the game is followed by a debriefing session. During debriefing, players exchange their experiences from every minigame and think of implications for improving BIV. This is mainly where learning takes place, i.e. the minigames focus on facilitating experiences that are reflected on during debriefing.

The instructor guides the discussion to make sure the corresponding guidelines are addressed. An overview of the minigames implemented in the software prototype is provided in Figure 1.

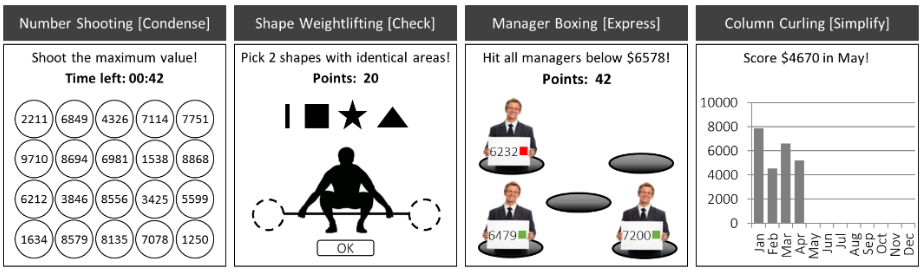

Figure 1: Minigames implemented in the software prototype

The first minigame is called "number shooting" and addresses the guideline CO 4.4 (Hichert & Faisst, 2015). This guideline recommends using graphical elements in tables to easily identify differences in size between numbers. The basic layout of the minigame is a grid of targets with numbers (similar to a table) without any graphical support. There is only a limited time for identifying the maximum value and "shooting" it. Hence, players have to compare the numeric value of every target inside the grid, which causes high cognitive effort. After the time has passed or the right target was shot, the minigame ends.

In the second minigame, which is called "shape weightlifting", the guideline CH 3.1 is covered (Hichert & Faisst, 2015). This guideline advises against using area comparisons in reports (like it is employed in pie charts) and instead suggests using length comparisons. To experience the difficulty of correctly comparing area sizes, players have to select two shapes with identical areas out of several different shapes and attach them to a weight bar. There are five rounds with decreasing differences between the areas of the shapes, which leads to increasing difficulty.

The next minigame is called “manager boxing” and is concerned with the guideline EX 2.5 (Hichert & Faisst, 2015). This guideline disadvises from using traffic light indicators in reports, since they distract from comprehending the actual numbers. To show this effect, players have to hit all managers holding numbers below a given threshold in a “Whac-A-Mole”-style minigame. At the beginning of the minigame, the traffic lights next to the numbers are consistent with the goal (i.e., showing red when the number is below the threshold). However, inconsistencies arise later in the game, leading to wrong decisions when players blindly trust the traffic light indicators.

The last minigame is called “column curling” and addresses the guideline SI 3.1 (Hichert & Faisst, 2015). This guideline recommends replacing value axes in column charts with data labels. Initially, players face an empty column chart with a target value displayed for the current month. By holding a key, they can “grow” a column for this month. When the key is released, the resulting column is the estimate for the month and a new target value is set for the next month. In doing so, players experience difficulties when estimating the exact height given only a value axis and gridlines.

2.6.7 Discussion and Conclusion

The software prototype described in this study is a first approach to improve BIV skills with a serious game. Due to its modular structure, minigames can be added or removed in forthcoming iterations of the human-centred design process. Since all minigames only use few interaction types (i.e., clicking and dragging), the game might also be ported to mobile devices. A possible limitation of the approach is the use of leaderboards: While they may motivate high-scoring players, they might also potentially embarrass players who “lose” against their peers. In addition, the presented game is fully digital. Since there are empirical investigations that indicate benefits of non-digital games (e.g., board games), these benefits might not be realized by our approach.

After its development will have finished, the prototype will be thoroughly evaluated in a between-subject experimental design. Participants will be asked to suggest improvements in a business report before and after playing the game. When this evaluation shows that the game leads to better suggestions concerning BIV, especially compared to more traditional learning methods, this might indicate that it is beneficial to use serious games to increase players' BIV skills. These games might then be tested in blended learning scenarios that combine both serious games as well as other learning methods for improving BIV skills. After thorough evaluation, the Dashboard Olympics might be used in several areas of application. First, educators in management information systems courses might want to add this game to their curriculum to improve BIV skills. Second, companies might use it to help employees create adequate reports for example with business intelligence applications. After the game has been adopted in practice, differences between students and practitioners (e.g., acceptance or learning outcomes) may be examined.

2.7 Essay: Architecture and Evaluation Design of a Prototypical Serious Game for Business Information Visualization

Authors: Christian Karl Grund
Michael Schelkle
Max Hurm
Professur für Wirtschaftsinformatik und Management Support
Universitätsstraße 16, 86159 Augsburg
christian.grund@wiwi.uni-augsburg.de
michael.schelkle@wiwi.uni-augsburg.de
max.hurm@student.uni-augsburg.de

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2.7.1 Abstract

Poorly visualized business reports may lead to wrong decisions caused by incomprehensible or misleading data. However, many companies still do not strive for adequate business information visualization (BIV), which may be due to a lack of knowledge about how to achieve it. To support managers in avoiding the pitfalls of incomprehensible reports, we are currently developing a serious game that helps players to learn about guidelines for adequate BIV. In this so-called “Dashboard Tournament”, players compete across several minigames that address specific BIV guidelines. The aim of this paper is to provide an understanding of the prototype’s architecture and to propose an experimental design for its evaluation. Researchers and practitioners may hence increase their understanding of how to design and evaluate serious games in the domain of business and information systems engineering.

2.7.2 Introduction

Poorly visualized business reports may lead to wrong decisions due to incomprehensible or misleading data (Ware, 2012). Despite these threats, many companies still do not strive for proper business information visualization (BIV) (Al-Kassab et al., 2014). One explanation for this is the lack of knowledge about adequate BIV practices and guidelines (Few, 2012). Experiential learning might be a way to sustainably increase this knowledge and therefore improve the way reports are designed (Kolb, 1984). Serious games are one form of experiential learning that has been used for decades to successfully convey business-related content by engaging players (Faria et al., 2009). However, despite the plethora of different serious games described in literature, BIV has thus far not been a dedicated aspect of them (Grund & Meier, 2016; Grund & Schelkle, 2016). To fill this gap, we are developing a serious game called “Dashboard Tournament” that aims to increase BIV capabilities among players by letting them compete across several minigames (Grund & Schelkle, 2016). Each minigame confronts players with insufficient BIV like pie charts, traffic lights, or crowded tables in reports. After describing the concept of the game in prior research (Grund & Schelkle, 2016), we aim to present its architecture and propose an experimental design for its evaluation in this paper. This may provide researches and practitioners with insights about how to develop and evaluate serious games in the domain of management reporting.

2.7.3 Theoretical Background and Development Method

Since serious games are concerned with improving player capabilities as well as providing an entertaining experience (Abt, 1987), both learning and motivation theories are used in literature to explain the benefits of serious games (Grund, 2015). For instance, they are often described as a form of experiential learning (Kolb, 1984). To explain the motivational effects of our game, we draw on self-determination theory (Deci & Ryan, 1985). According to this theory, video games in general foster intrinsic motivation by enabling perceived competence, autonomy, and relatedness (Ryan et al., 2006). We hence also expect to increase intrinsic motivation with our game by satisfying these needs. Perceived competence may be fostered by players succeeding in the different minigames and earning points for doing so. Relatedness may be achieved by letting players compete in the same room and using leaderboards that allow comparisons with other players. Last, a sense of autonomy may be achieved by players being able to choose their own approaches of how to succeed in the minigames. To develop the Dashboard Tournament, we employ the human-centred design process (Grund & Schelkle, 2016). In the following, we describe the architecture of an evolutionary prototype that resulted from the first iteration of this development process.

2.7.4 Architecture of the Dashboard Tournament

The prototype of the Dashboard Tournament currently features a singleplayer mode that comprises four minigames (Grund & Schelkle, 2016). To implement the prototype, we used the game engine Unity with C# as the programming language. An overview of the game's architecture is provided in Figure 1.

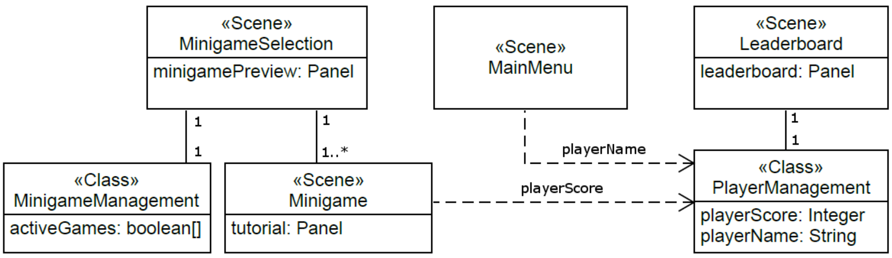

Figure 1: Architecture of the Dashboard Tournament

The game comprises different scenes (i.e., screens that players will access during the course of the game), classes that store the data necessary for the scenes to operate as well as several panels (i.e., graphical elements inside the scenes). First, players enter the main menu ("MainMenu") where they can enter their nicknames, which will be stored in the "PlayerManagement" class. Afterwards, a scene where the next minigame gets selected at random ("MinigameSelection") is shown. The different minigames are represented as "minigamePreview" panels in this scene. After the minigame that has to be played is selected, players access the respective scene for that minigame ("Minigame"). Each minigame features a tutorial panel that provides players with information regarding the objective of the current minigame and how to play it. When the minigame is finished, scores are saved in the "PlayerManagement" class and players enter a scene for displaying leaderboards ("Leaderboard"). Here they will find their score on a leaderboard panel. Afterwards, they return to the scene "MinigameSelection" as long as there are minigames left to be played. This information is stored in the "MinigameManagement" class. Although gameplay data is currently only available at runtime, a log file is going to be available on the server in later versions of the game for analysis purposes. Due to the prototype's component-based architecture, minigames may be added or removed in future iterations of the development process. In addition, multiplayer functionality will be added by defining one instance of the game as a host that selects minigames and keeps all clients synchronized.

2.7.5 Evaluation of the Prototype and Conclusion

To evaluate the game after its development will be finished (i.e., multiplayer functionality is added), we plan to conduct a laboratory experiment using a multivariate 1x3 between-group design (see Table 1). Power analysis revealed that for statistically significant results ($d = 0.8; \alpha = 0.05; 1 - \beta = 0.95$), each group should consist of 35 participants who are randomly assigned from a pool of students in business and economics programs (i.e., prospective managers and report designers).

Table 1: Experimental Design of the Evaluation

Group	Pretest	Treatment	Post-Experience	Posttest
1	Suggestions	Competition	Intrinsic Motivation	Suggestions
2	Suggestions	Singleplayer	Intrinsic Motivation	Suggestions
3	Suggestions	Presentation	Intrinsic Motivation	Suggestions

The treatments differ in how they aim to increase BIV capabilities. In the first treatment, participants play the Dashboard Tournament in a competition. The second treatment uses a modified version of the game, where there is no competition at all. This condition is used to isolate the effect of providing a competition: If the singleplayer version leads to the same benefits, the game may be easier to use in practice, since it would not require several managers to attend the same session. Last, there is a treatment with only a presentation about BIV guidelines, serving as a control group. To assess the motivational benefits of the game, we conduct post-experience questionnaires regarding perceived competence, autonomy, and relatedness as well as intrinsic motivation of participants by using the intrinsic motivation inventory (Ryan & Deci, 2000). To assess learning outcomes, pre- and posttests are going to address participants' BIV capabilities. For this purpose, participants are provided with different examples of business reports and are requested to suggest improvements. The provided reports suffer from inadequate BIV that is addressed by the guidelines covered in the different treatments. We can hence check whether improvements suggested by participants comply with the BIV guidelines. The pretests also help in determining prior knowledge of participants (e.g., courses or practical experience).

By comparing the post-experience questionnaires of all treatments, we may investigate whether playing the game leads to increased motivation compared to hearing a presentation. To examine the effect of setting up a competition, we may look for differences in motivation between providing a competition between players and simply playing the minigames (first and second treatment). We may also compare the learning outcomes in all treatments to see whether participants who play the game actually show increased BIV capabilities compared to participants only hearing a presentation. Last, we intend to examine correlations between motivation and learning outcomes.

In summary, this evaluation may show that the Dashboard Tournament leads to increased motivation as well as increased learning outcomes. This may encourage both researchers and practitioners to consider using serious games in the domain of management reporting. Since our approach appears to be the first serious game about BIV guidelines (Grund & Meier, 2016; Grund & Schelkle, 2016), we intend to investigate its usage in this domain in future research. Especially the importance and effects of competition can be examined in further studies. By describing an architecture as well as proposing an evaluation of our game, we also aim to support building and evaluating these games.

2.8 Essay: Visualisieren spielend erlernen – Ein Serious Game zur Verbesserung von Managementberichten

Authors:	Christian Karl Grund Michael Schelkle Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg christian.grund@wiwi.uni-augsburg.de michael.schelkle@wiwi.uni-augsburg.de

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2.8.1 Zusammenfassung

Aktuelle Studien belegen, dass viele Managementberichte ihren eigentlichen Zweck – Klarheit in Entscheidungssituationen zu schaffen – nicht ausreichend erfüllen. Eine Ursache hierfür ist die mangelhafte Aufbereitung von Informationen aufgrund der, insbesondere bei Nachwuchsführungskräften, oft unzureichenden Kenntnisse bei der Informationsvisualisierung. Eine vielversprechende Möglichkeit, das Wissen zur zweckmäßigen Gestaltung von Managementberichten nachhaltig zu verinnerlichen, bietet erfahrungsbasiertes Lernen mithilfe von Serious Games. Dieser Beitrag stellt ein entsprechendes prototypisches Serious Game vor. Hierbei treten Teilnehmer im sogenannten „Dashboard Tournament" gegeneinander an, bei dem sie verschiedene Minispiele bestreiten. Jedes Minispiel adressiert eine spezifische Richtlinie aus den „International Business Communication Standards", die auf Praxiserfahrungen sowie Erkenntnissen aus der Wissenschaft beruhen. Eine erste empirische Evaluation im Rahmen einer Lehrveranstaltung zeigt, dass das Spiel positiv aufgenommen wird und die vermittelten Richtlinien grundsätzlich erkannt werden.

2.8.2 Informationsvisualisierung in Unternehmen

„Man kriegt ja regelmäßig den Risikobericht, da kann man nachgucken. Und da hat man so eine kleine Ampel drin, mit den drei Farben rot, gelb, grün. Und wenn es grün ist, und der überwiegende Teil war eben im grünen Bereich, (…) dann scheint es so zu gehen" (zitiert nach Mertens, 2009). Dieser Erklärungsversuch eines Verwaltungsrats für die nicht rechtzeitig erkannte Krise bei der Sachsen LB zeigt, was aktuelle Untersuchungen bestätigen: Viele Managementberichte erfüllen ihren eigentlichen Zweck – Klarheit in Entscheidungssituationen zu schaffen – nicht ausreichend.

So zeigt bspw. die KPI-Studie 2013, dass die Hälfte der Unternehmen im DACH-Gebiet mit ihrem Reporting unzufrieden ist (Gräf et al., 2013). Ursache hierfür ist u.a. die mangelhafte Aufbereitung von Informationen. Hierdurch steigen der Aufwand für die Informationsverarbeitung sowie die Gefahr von gravierenden Fehlentscheidungen durch Missverständnisse und Fehlinterpretationen (Hichert & Faisst, 2014). Zwar sehen Unternehmen laut Forrester Research die Visualisierung von Informationen zunehmend als essenziell an, um Gefahren abzuwenden und Chancen zu ergreifen (Evelson & Yuhanna, 2012). Jedoch haben ca. zwei Drittel der Unternehmen bislang keine Richtlinien zur Darstellung von Geschäftsgrafiken und Tabellen (Proff & Wiener, 2012). Eine Erklärung hierfür ist, dass insbesondere Nachwuchsführungskräfte aus betriebswirtschaftlichen Studiengängen selten wissen, worauf es bei sinnvoller Informationsvisualisierung ankommt. „In der Schule oder Universität gab es schließlich kein Fach oder kaum ein Seminar, in dem gutes Information Design vermittelt wurde" (Kohlhammer et al., 2013).

In der Literatur finden sich dagegen zahlreiche Ansätze, wie Führungsinformationen zweckmäßig dargestellt werden sollten. So beschreiben bspw. Ware (2012) und Tufte (2010) allgemeine Grundsätze für sinnvolle Informationsvisualisierung. Einen konkreten Vorschlag im Unternehmenskontext stellen die „International Business Communication Standards" (IBCS) dar. Sie beruhen auf Praxiserfahrungen sowie Erkenntnissen aus der Wissenschaft (vgl. Hichert & Faisst, 2015). Die konkreten Gestaltungsrichtlinien werden mit dem Akronym „SUCCESS“ abgekürzt. Jeder Buchstabe steht für eine Kategorie, auf die bei der Erstellung eines Managementberichts zu achten ist (siehe Abb. 1).

Abbildung 1: Struktur der International Business Communication Standards

Diese sieben Kategorien lassen sich in konzeptionelle, semantische und wahrnehmungsbezogene Gestaltungsrichtlinien gliedern. Die konzeptionellen Gestaltungsrichtlinien bestehen aus den Kategorien „Say“ und „Structure“ und beschreiben die strukturierte Wiedergabe von Kerninhalten in Berichten. „Unify“ beinhaltet Richtlinien mit Bezug zur Semantik, insbesondere mit dem Fokus auf einheitliche Notationsstandards. Die wahrnehmungsbezogenen Gestaltungsrichtlinien setzen sich aus den Kategorien „Express“, „Simplify“, „Condense“ sowie „Check“ zusammen und beschreiben das Visualisierungsdesign bei Managementberichten. Um dieses Visualisierungsdesign nachhaltig zu verbessern, stehen die wahrnehmungsbezogenen Gestaltungsrichtlinien in unserem Projekt im Fokus.

Ziel des Projekts „Dashboard Tournament“ ist es, bei Fach- und Führungskräften das Bewusstsein für die menschliche Wahrnehmung und deren Limitationen zu erhöhen, um Missverständnisse und Fehlinterpretationen sowie deren betriebswirtschaftliche Folgen zu reduzieren. Hierfür wird in diesem Beitrag ein prototypisches Serious Game vorgestellt, das wahrnehmungsbezogene Gestaltungsrichtlinien der IBCS vermittelt und zunächst in der Hochschullehre sowie anschließend auch in Unternehmen eingesetzt werden soll. Der Beitrag verfolgt zwei Ziele: Zum einen soll er Praktiker sowie Wissenschaftler für das Potenzial von Serious Games zur nachhaltigen Vermittlung von Lerninhalten im Management Reporting sensibilisieren. Zum anderen soll er die anspruchsvolle Erstellung dieser Serious Games erleichtern, indem er anhand eines konkreten Ansatzes aufzeigt, wie man mit konkurrierenden Spannungsfeldern bei der Gestaltung von Serious Games umgehen kann.

2.8.3 Serious Games im Management Reporting

In der Wirtschaftsinformatik gewinnen Serious Games als Lernform insbesondere vor dem Hintergrund der zunehmenden Popularität des Forschungsgebiets „Gamification" an Bedeutung. Gamification beschreibt den Einsatz von Spielelementen in einem spielfremden Kontext (Deterding et al., 2011). Dabei findet hauptsächlich eine Fokussierung auf die Motivation von bestimmten Verhaltensweisen der Spieler statt. Im Gegensatz hierzu sind Serious Games vollständige Spiele, die neben der Unterhaltung der Spieler auch die Weiterentwicklung ihrer Fertigkeiten zum Ziel haben (Abt, 1987).

In der Literatur gibt es zahlreiche Erklärungen, wie Serious Games zum Lernerfolg beitragen (Grund, 2015). Ein oft verwendeter Ansatz ist dabei die Theorie des erfahrungsbasierten Lernens. Demnach sind konkrete Erfahrungen für erfolgreiches Lernen ausschlaggebend (Kolb, 1984). In einem sogenannten erfahrungsbasierten Lernzyklus machen Lernende zunächst eine konkrete Erfahrung und reflektieren diese anschließend. Aus dieser Reflexion bilden sie sich ein abstraktes Modell und experimentieren daraufhin mit ihrer Umgebung, was wiederum zu neuen konkreten Erfahrungen führt. In Serious Games kann genau dieser Lernzyklus systematisch durchlaufen werden, da Spiele durch ihre Interaktivität Raum für konkrete Erfahrungen sowie Experimente mit der Spielumgebung bieten.

Zwar werden Serious Games bereits seit mehreren Jahrzehnten eingesetzt, um betriebswirtschaftliche Lerninhalte zu vermitteln (Faria et al., 2009) und eignen sich grundsätzlich auch für die Verbesserung des Entscheidungsverhaltens von Führungskräften (Grund & Meier, 2016). Ein Serious Game, das die Informationsvisualisierung im Management Reporting behandelt, konnte bislang jedoch nicht identifiziert werden (Grund & Schelkle, 2016). Um diese Lücke zu schließen und das Potenzial von Serious Games auch in diesem Bereich nutzen zu können, wird im Folgenden ein solches Serious Game vorgestellt. Zunächst wird jedoch auf die verschiedenen Spannungsfelder eingegangen, auf die es bei der Gestaltung von Serious Games zu achten gilt.

2.8.4 Spannungsfelder bei der Gestaltung von Serious Games

Bei der Gestaltung von Serious Games gibt es verschiedene, teilweise konkurrierende Ziele. Im Wesentlichen gilt es, die Themenfelder Realität (zu vermittelnde Inhalte), Spiel (eine erfüllende Beschäftigung) und Bedeutung (Vermittlung von Lerninhalten und Fertigkeiten) zu balancieren (Harteveld et al., 2010). Hierbei ergeben sich mehrere mögliche Spannungsfelder, die von Harteveld et al. (2010) vorgestellt wurden und im Folgenden beschrieben werden (vgl. Abb. 2).

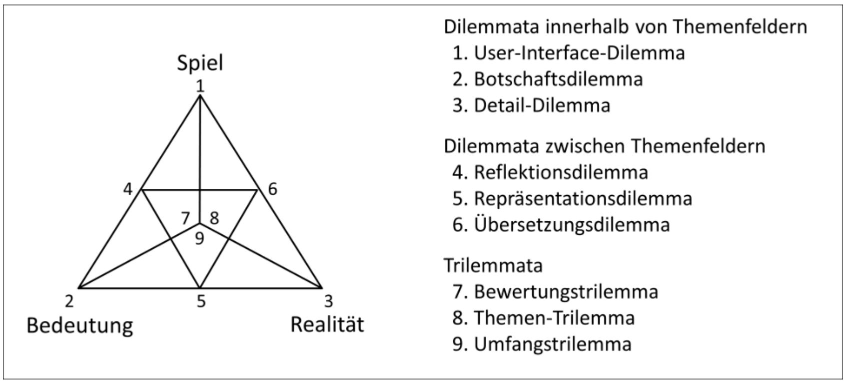

Abbildung 2: Spannungsfelder bei der Gestaltung von Serious Games (Harteveld et al., 2010)

Das User-Interface-Dilemma liegt im Themenfeld „Spiel“ und bezieht sich auf die Komplexität der Interaktionsmöglichkeiten der Nutzer mit dem Spiel: Hohe Komplexität führt zu hohem Lernaufwand und verringert die Wahrscheinlichkeit, dass jeder Nutzer das Spiel gerne spielt. Geringe Komplexität limitiert wiederum die Interaktionsmöglichkeiten der Nutzer mit dem Spiel, was zu geringeren Lernergebnissen führen kann. Bei dem Botschaftsdilemma im Themenfeld „Bedeutung“ werden Serious

Games adressiert, die mehrere Botschaften vermitteln möchten. Hier müssen die Lerninhalte priorisiert werden, um den Fokus auf die wichtigsten Botschaften zu legen. Mit dem Detail-Dilemma im Themenfeld „Realität“ wird der Grad an Detaillierung der Spielumgebung angesprochen. Einerseits können Spieler durch einen hohen Detaillierungsgrad Gegenstände und Umgebungen leichter erkennen. Andererseits lenkt zu viel Detaillierung u.U. vom Wesentlichen ab.

Das Reflektionsdilemma beschreibt einen Konflikt zwischen den Themenfeldern „Spiel“ und „Bedeutung“. In einem Spiel konzentrieren sich Spieler idealerweise vollständig auf ihre Aufgabe und vergessen dabei ihre Umgebung („Immersion“). Dies kann allerdings dazu führen, dass die Reflektion über die erlebten Geschehnisse nicht in ausreichendem Maße stattfindet, die Bedeutung des Spielgeschehens also unverstanden bleibt. Im Repräsentationsdilemma, das sich zwischen den Themenfeldern „Bedeutung“ und „Realität“ ergibt, wird die zielgerichtete Vereinfachung der Realität zugunsten von Lernergebnissen beschrieben. Metaphorische Handlungen blenden bspw. komplexe, für die Botschaft des Spiels nicht relevante Handlungen aus. Dies führt im Falle von zu stark vereinfachten Abläufen u.U. dazu, dass Spieler diese nicht in die Realität übertragen können. Zu genau abgebildete Abläufe stören hingegen die Fokussierung auf die Bedeutung. Das Übersetzungsdilemma zwischen den Themenfeldern „Spiel“ und „Realität“ thematisiert die Herausforderung, dass es in Spielen schwierig ist, jeden Aspekt der Realität abzubilden. Wird das Themenfeld „Spiel“ priorisiert, sind unrealistische Ergebnisse möglich. Bei der Priorisierung des Themenfelds „Realität“ wiederum könnte ein Spiel entstehen, das kaum jemand spielen möchte.

Das Bewertungstrilemma geht auf die Bewertung von Spielerleistungen ein. Eine transparente und motivierende Bewertung ist sehr wichtig für die Reflektion über die Lerninhalte. Aus der „Spiel“-Perspektive versprechen höhere Punktzahlen ein besseres Erlebnis, wohingegen geringere Punktzahlen leichter nachzuverfolgen sind. Das Themen-Trilemma bezieht sich darauf, dass das Thema eines Spiels schwierig zu vermitteln sein kann. Dies ist darin begründet, dass die Realität in Bezug auf das gewählte Thema u.U. komplexer ist, als sie in einem Spiel dargestellt werden kann. Im

Umfangstrilemma geht es darum, den Zusammenhang zwischen der Botschaft und dem Umfang des Spiels zu berücksichtigen. So sollte jedes zusätzliche Element des Spiels auch die Spielerfahrung verbessern, zu Lernergebnissen beitragen sowie die Realität in angemessenem Umfang widerspiegeln.

Zusammenfassend können bei der Gestaltung von Serious Games einige Spannungsfelder auftreten, auf die es zu achten gilt. Das im folgenden Abschnitt vorgestellte Serious Game „Dashboard Tournament“ schlägt eine konkrete Möglichkeit vor, wie mit diesen Spannungsfeldern im Anwendungsfall Management Reporting umgegangen werden kann.

2.8.5 Entwicklung und Inhalte des Spiels “Dashboard Tournament”

Das Ziel bei dem „Dashboard Tournament“ besteht darin, Fach- und Führungskräften grundlegende Gestaltungsrichtlinien zur Informationsvisualisierung nachhaltig zu vermitteln. Die Teilnehmer bestreiten verschiedene Minispiele, wobei jedes davon eine spezifische Gestaltungsrichtlinie aus den IBCS adressiert. Im Folgenden werden die Entwicklungsmethode, der Ablauf des Spiels sowie bislang implementierte Minispiele aus dem Dashboard Tournament beschrieben.

2.8.5.1 Entwicklungsmethode

In der Literatur werden einige Entwicklungsmethoden für die Erstellung von Serious Games vorgeschlagen (z.B. de Freitas & Jarvis, 2006, 2009; Kelly et al., 2007; Moreno-Ger et al., 2008; Nadolski et al., 2008). Zwar gibt es unter diesen Methoden bislang keinen etablierten Standard. Sie stimmen jedoch darin überein, dass für die Entwicklung von erfolgreichen Serious Games sowohl die Lernziele als auch unterhaltsame Erfahrungen eine wichtige Rolle spielen. Nachdem letztere nur durch das Spielen selbst evaluiert werden können, sollte eine Entwicklungsmethode mehrere Iterationen zum Testen des Spiels mit potentiellen Nutzern durchlaufen. Daher wird in diesem Projekt der menschenzentrierte Gestaltungsprozess (siehe Abb. 3) angewendet (Grund & Schelkle, 2016; ISO, 2010), der in der Forschungsdomäne „Human Computer Interaction“ (HCI) verbreitet ist (Earthy et al., 2001). Zusätzlich werden die oben aufgeführten Spannungsfelder bei der Gestaltung von Serious Games berücksichtigt.

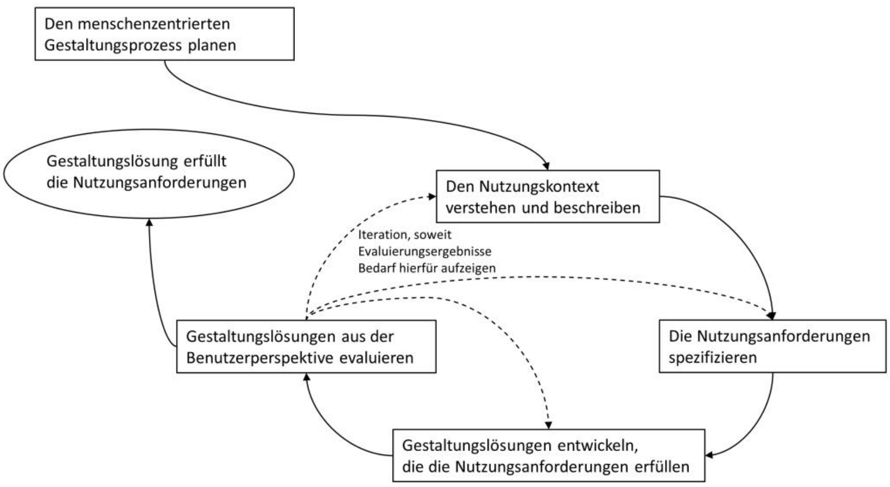

Abbildung 3: Menschenzentrierter Gestaltungsprozess (ISO, 2010)

Bevor die einzelnen Phasen des menschenzentrierten Gestaltungsprozesses durchlaufen werden, gilt es, den grundsätzlichen Aufbau des Serious Games zu planen. Das „Dashboard Tournament“ ist ein zweidimensionales Spiel, das Richtlinien für angemessene Informationsvisualisierung anhand eines Wettbewerbs zwischen Spielern vermittelt. Grundlage für die Richtlinien sind die IBCS, die auf übliche Fehler bei der Informationsvisualisierung hinweisen. Der Wettbewerb besteht aus mehreren Minispielen, die jeweils eine spezifische Richtlinie adressieren. Um den Wettbewerbsgedanken hervorzuheben, treten die Spieler dabei gegeneinander an, daher der Name „Dashboard Tournament“.

In der ersten Phase der Entwicklung gilt es, den Nutzungskontext zu verstehen und zu beschreiben. Beim Dashboard Tournament besteht die Zielgruppe aus Studierenden in einem universitären Seminar zum Thema Management Reporting (d.h. zukünftigen Visualisierungsexperten und Nachwuchsführungskräften). Das Seminar enthält in der ersten Woche bereits ein Tutorial zu Reporting-Software, das in einem Computerraum mit 30 Rechnern im selben Netzwerk stattfindet. Daher dienen diese Rahmenbedingungen als Nutzungskontext für das Dashboard Tournament.

Als nächstes sind die Nutzungsanforderungen zu spezifizieren. Als Nutzer werden sowohl die Organisation (d.h. die Universität) als auch die Spieler (d.h. die Studierenden) verstanden. Aus Perspektive der Organisation ist es wichtig, dass die Spieler den Lerninhalt (d.h. Ansätze zur Verbesserung von Informationsvisualisierung) verstehen. Aus Sicht der Spieler ist zusätzlich eine unterhaltsame Erfahrung (z.B. Spaß haben, im Spiel vertieft sein etc.) wünschenswert.

Für die Entwicklung von Gestaltungslösungen werden zwei Schritte durchgeführt: Zunächst werden die IBCS-Richtlinien in einer Brainstorming-Sitzung mit mehreren Spielmechaniken zusammengeführt, um Minispiele zu entwerfen. Diese Form der Ideenfindung eignet sich, um kreative Ideen zu entwickeln und gleichzeitig die angestrebten Lernergebnisse zu berücksichtigen. Anschließend werden die entworfenen Minispiele als Softwareprototyp mit der Spiel-Engine „Unity“ implementiert.

2.8.5.2 Ablauf des Spiels und Auflösung der Spannungsfelder

Zu Beginn des Wettbewerbs befinden sich die Teilnehmer in einem Raum mit mehreren Computern. Nachdem ein Übungsleiter den Ablauf erläutert hat, wird das erste Minispiel per Zufall ausgewählt. Durch die Aufteilung der Richtlinien auf verschiedene Minispiele wird das Botschaftsdilemma aufgelöst: Anstatt mehrere Verstöße gegen sinnvolle Informationsvisualisierung gleichzeitig anzusprechen, thematisiert jedes Minispiel nur eine einzelne Richtlinie. Die Aufgabe des ausgewählten Minispiels sowie die Handlungsmöglichkeiten werden den Teilnehmern anschließend in Form von kurzen

Anweisungen auf dem Bildschirm angezeigt. Da für die Vermittlung von Richtlinien vergleichsweise wenig Interaktion notwendig ist, wurde im User-Interface-Dilemma auf eine sehr einfache Bedienbarkeit geachtet. Die Nutzerinteraktion beschränkt sich auf wenige Klicks, was ebenfalls eine Portierung als mobile Version (bspw. für Tablets) ermöglicht. Sobald jeder Teilnehmer die Anweisungen verstanden hat, beginnt das entsprechende Minispiel, bei dem die Spieler mit mangelhafter Informationsvisualisierung konfrontiert werden. Somit lernen die Teilnehmer diese als ein Hindernis zu verstehen, das es auf dem Weg zum Erfolg zu überwinden gilt.

Bei den Minispielen wurde in Bezug auf das Repräsentationsdilemma auf eine realitätsgetreue Darstellung von vollständigen Managementberichten zugunsten der Lernergebnisse bei der Informationsvisualisierung verzichtet. Die Spieler befinden sich demnach nicht tatsächlich vor Managementberichten, sondern vor abstrakten Aufgaben, die lediglich Elemente aus Berichten verwenden. Die Minispiele verzichten zudem auf rein dekorative Elemente, was das Detail-Dilemma zugunsten von realitätsgetreuen Berichtselementen auflöst. Nachdem jeder Teilnehmer die Aufgabe des Minispiels gelöst hat, endet dieses zunächst mit direktem Feedback auf dem Bildschirm jedes Teilnehmers. Dabei kann in jedem Minispiel eine Punktzahl zwischen 0 und 100 Punkten erreicht werden, die den Teilnehmern mitgeteilt wird. Anschließend zeigt das Spiel ein Leaderboard an, das die Punktzahlen der Teilnehmer miteinander vergleicht. Dieser Wettbewerbsmechanismus wird häufig in Gamification-Anwendungen eingesetzt, um Nutzer zu besseren Leistungen zu motivieren. Sollten bereits mehrere Minispiele absolviert worden sein, wird zusätzlich ein globales Leaderboard angezeigt, das den Gesamtpunktestand der Teilnehmer vergleicht. Damit dienen die dargestellten Punktzahlen mit Bezug zum Bewertungstrilemma nicht dazu, die Realität abzubilden bzw. den Lernerfolg zu reflektieren, sondern um den Wettbewerb aus dem Themenfeld „Spiel“ zu begünstigen. Dieser Wettbewerb soll im Hinblick auf das Reflektionsdilemma einen sog. „Flow“-Zustand bewirken. Gleichzeitig ermöglichen die Herausforderungen in Form von mangelhafter Informationsvisualisierung, dass Spieler die Bedeutung des Spiels reflektieren. Dies hat auch Einfluss auf das Übersetzungsdilemma: Die genaue

Wiedergabe der Realität hat für die Vermittlung von abstrakten Gestaltungsrichtlinien weniger Bedeutung als ein funktionierender Wettbewerb zwischen den Spielern.

Im Anschluss an das Spiel findet eine Diskussion der Minispiele mit dem Übungsleiter statt. Bei diesem sogenannten „Debriefing" ist das Ziel, dass die Teilnehmer selbstständig erkennen, welche Probleme im Zusammenhang mit schlechter Informationsvisualisierung auftreten können und welche Maßnahmen erforderlich sind, um diese zu verhindern. Nachdem die Teilnehmer selbst überlegt haben, welche Maßnahmen sinnvoll sein könnten, werden ihnen die entsprechenden Richtlinien aus den IBCS vorgestellt. Während des Debriefings wird durch einen Bezug auf Managementberichte auf das Themenfeld „Realität" sowie durch Reflektion der Erfahrungen aus dem Spiel auf das Themenfeld „Bedeutung" eingegangen, um das Themen-Trilemma aufzulösen. Das Umfangstrilemma wird in dem Spiel durch einen komponentenorientierten Aufbau aufgelöst, d.h. jeder Übungsleiter kann die zu spielenden Minispiele vor dem Wettkampf auswählen und somit den Umfang sowie die Inhalte an die entsprechende Gruppe anpassen.

2.8.5.3 Exemplarische Minispiele aus dem Dashboard Tournament

Um zu demonstrieren, dass Minispiele für jede Kategorie der wahrnehmungsbezogenen Gestaltungsrichtlinien aus den IBCS (Condense, Check, Express und Simplify) erstellt werden können, wird im Folgenden hierfür jeweils exemplarisch ein bereits prototypisch implementiertes Minispiel aus dem Dashboard Tournament beschrieben.

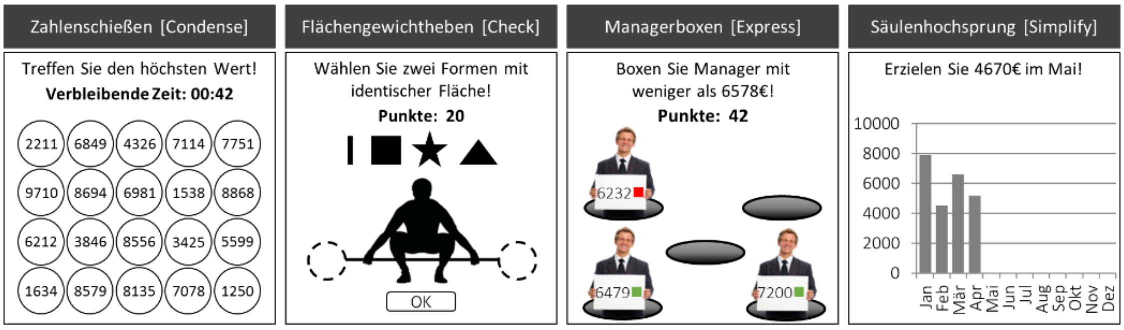

Abbildung 4: Aufbau der Minispiele im Dashboard Tournament

Condense: „Zahlenschießen“

Das erste Minispiel trägt den Namen „Zahlenschießen“ und adressiert die Gestaltungsrichtlinie CO 4.4 aus den IBCS. Diese Richtlinie empfiehlt, Tabellen für das leichtere Verständnis des Betrachters mit grafischen Elementen zu versehen. Damit soll auf die Schwierigkeit hingewiesen werden, Auffälligkeiten in Tabellen zu erkennen, die keine grafische Unterstützung anbieten. Der Spieler macht in diesem Minispiel demnach die Erfahrung, dass hoher kognitiver Aufwand entsteht, wenn Zahlen sequentiell miteinander verglichen werden müssen.

Um dem Spieler diese Schwierigkeit zu verdeutlichen, besteht die Aufgabe des Minispiels darin, zwischen mehreren Zielen das Maximum zu identifizieren. Hierfür hat jeder Spieler nur begrenzt Zeit, bevor das Minispiel automatisch endet (vgl. Abb. 4). Am Ende des Minispiels wird dem Spieler seine Punktzahl angezeigt, die von der verbleibenden Zeit abhängt: Die Punktzahl verteilt sich gleichmäßig anhand der verbleibenden Anzahl an Sekunden. Damit erhält der Spieler mehr Punkte, je schneller er die Aufgabe löst.

Check: „Flächengewichtheben“

Das Minispiel „Flächengewichtheben“ bezieht sich auf die Gestaltungsrichtlinie CH 3.1 der IBCS. Sie schlägt vor, Flächenvergleiche in Managementberichten zu vermeiden und stattdessen Längenvergleiche (wie bspw. Säulen- oder Balkendiagramme) zu bevorzugen. Um dies zu verdeutlichen, machen Spieler in diesem Minispiel die Erfahrung, dass korrekte Vergleiche zwischen Flächen (wie bspw. in Kreisdiagrammen) für die menschliche Wahrnehmung schwierig sind.

Zu Beginn dieses Minispiels sieht der Spieler einen Gewichtheber mit einer Stange ohne Gewichte sowie mehrere verschieden große Formen (siehe Abb. 4). Die Aufgabe besteht darin, zwei Formen mit identischer Fläche an den jeweiligen Enden der Stange zu platzieren. Hierfür kann der Spieler per Drag & Drop mehrere Konstellationen zunächst ausprobieren, bevor er die Auswahl bestätigt. Wählt der Spieler die korrekten Gewichte aus (d.h. Formen mit identischer Fläche), stemmt der Gewichtheber die Stange in einer kurzen Animation und der Spieler erhält Punkte. Sind zwei Gewichte mit unterschiedlicher Fläche ausgewählt, kippt der Gewichtheber in die Richtung des schwereren Gewichts und der Spieler erhält keine Punkte. Insgesamt werden in diesem Minispiel fünf Runden gespielt, wobei in jeder Runde die Anzahl der vorhandenen Formen steigt und der Unterschied zwischen ihren Flächen geringer wird, was den Schwierigkeitsgrad erhöht.

Express: „Managerboxen“

Das sogenannte “Managerboxen” nimmt Bezug auf die Gestaltungsrichtlinie EX 2.5 der IBCS, die besagt, dass Managementberichte auf Ampeldarstellungen verzichten sollten, da diese nur eine geringe Informationsdichte aufweisen und den Fokus von konkreten Zahlen ablenken. Dies wird in einem Minispiel vermittelt, in dem Spieler die Erfahrung machen, dass das alleinige Vertrauen auf Ampelgrafiken zu Fehlern führen kann.

Zu Beginn des Minispiels sieht der Spieler fünf Löcher, die auf dem Bildschirm verteilt sind, sowie einen Zielwert im oberen Bereich des Bildschirms. Im Laufe des Spiels erscheinen aus diesen Löchern Manager, die Zahlen samt Ampelgrafik (grün oder rot) präsentieren und nach kurzer Zeit wieder in den Löchern verschwinden (vgl. Abb. 4). Der Spieler muss jeden Manager boxen, der eine Zahl präsentiert, die kleiner als der vorgegebene Zielwert ist. Zunächst zeigen sämtliche Ampeln rot an, wenn die Zahl kleiner ist als der Zielwert und grün, wenn die Zahl gleich groß oder größer ist.

Der Spieler lernt hierbei, sich auf die Ampelfarben zu verlassen. Später zeigen jedoch auch Manager, die eine Zahl unterhalb des Zielwerts präsentieren, z.T. eine grüne Ampelfarbe an. Wenn der Spieler also nicht mehr auf die Zahlen, sondern nur noch auf die Ampelfarben achtet, wird er in der zweiten Phase des Spiels Fehler machen.

Für jeden korrekt geboxten Manager erzielt der Spieler Punkte. Gleichzeitig werden Punkte abgezogen, wenn der Spieler einen Manager boxt, dessen Zahl gleich dem Zielwert oder größer ist. Es werden ebenfalls Punkte abgezogen, wenn ein Manager nicht geboxt wird, dessen Zahl kleiner als der Zielwert ist. Der Spieler kann insgesamt jedoch nicht weniger als null Punkte erreichen.

Simplify: „Säulenhochsprung“

Das Minispiel „Säulenhochsprung“ thematisiert die Beschriftung von Säulendiagrammen, was von der Gestaltungsrichtlinie SI 3.1 aus den IBCS aufgegriffen wird. Diese Richtlinie besagt, dass Säulen bei vorhandenem Platz stets mit ihrem Wert beschriftet werden sollten, um Berichtsempfängern eine möglichst genaue Einschätzung der Größen zu ermöglichen. In diesem Minispiel machen Spieler demnach die Erfahrung, dass Werte in einem unzureichend beschrifteten Säulendiagramm nur schwer abzuschätzen sind.

Dem Spieler wird zunächst ein leeres Säulendiagramm angezeigt, das zwölf Monate auf der Abszisse und mehrere Zahlen auf der Ordinate beinhaltet (siehe Abb. 4). Für jeden Monat wird dem Spieler ein Zielwert zwischen 1000 und 9000 im oberen Bereich des Bildschirms vorgegeben, den es zu erreichen gilt. Durch das gedrückt Halten einer Taste kann der Spieler die Säulenhöhe für den aktuellen Monat beeinflussen. Diese Säule wird größer, je länger der Spieler die Taste gedrückt hält. Sobald der Spieler die Taste loslässt, gilt die entstandene Säule als Schätzung für den aktuellen Monat. Anschließend wird ein neuer Zielwert für den nächsten Monat vorgegeben. Dieser Vorgang wiederholt sich, bis alle zwölf Monate mit einer Säule versehen sind (vgl. Abb. 4).

Nach Schätzung aller Monate werden dem Spieler grafisch die Abweichungen zur tatsächlichen Größe der Säulen sowie die erreichte Punktzahl angezeigt. Die Punktzahl für eine Säule verteilt sich gleichmäßig anhand der Abweichung von der korrekten Säulenhöhe. Die Punktzahl für das gesamte Minispiel ergibt sich anschließend aus dem Durchschnitt der Punktzahlen der einzelnen Säulen für jeden der zwölf Monate.

2.8.6 Ergebnisse einer ersten Evaluation

Um die Spielerfahrung sowie die inhaltlichen Aspekte bezüglich der Gestaltungsrichtlinien zur Informationsvisualisierung zu überprüfen, wurde eine erste empirische Evaluation des Spiels durchgeführt. Hierbei nahmen 19 Studierende im Rahmen eines Seminars zum Thema Management Reporting teil. Nach kurzer Einweisung spielten diese das Dashboard Tournament im Einzelspielermodus gegen fiktive Charaktere. Anschließend füllten die Studierenden den in Abschnitt 2.8.5.1 angesprochenen Fragebogen aus. Zur Überprüfung der Lerninhalte enthielt der Fragebogen Screenshots der Minispiele samt der Frage, welche Gestaltungsrichtlinie zur Informationsvisualisierung das jeweilige Minispiel anspricht. Obwohl die Gestaltungsrichtlinien im Spieldurchlauf nicht explizit angesprochen wurden, waren sie ein Bestandteil des Seminars, weshalb Studierende grundsätzlich in der Lage sein konnten, sie zu erkennen.

Im Folgenden werden die deskriptive Statistik der Skalen zur Spielerfahrung sowie deren Reliabilität (Cronbachs α) diskutiert (siehe Tab. 1). Die dargestellten Skalen stammen aus dem Game Experience Questionnaire (IJsselsteijn et al., 2008).

Tabelle 1: Deskriptive Statistik der Skalen zur Spielerfahrung und Reliabilität

Skala	N	Min	Max	MW	Std.-Abw.	Cronbachs α
Competence	19	2,00	4,00	3,00	0,50	0,82
Immersion	18	0,40	3,80	1,87	0,94	0,88
Flow	19	0,40	3,80	2,46	0,85	0,80
Tension/Annoyance	19	0,00	2,33	0,75	0,64	0,61
Challenge	19	0,40	3,40	1,77	0,82	0,75
Negative Affect	18	0,00	2,50	0,72	0,71	0,75
Positive Affect	19	1,40	3,80	2,67	0,64	0,81

Wie in Tab. 1 zu sehen, weisen sämtliche Skalen außer „Tension/Annoyance“ zufriedenstellende Werte bezüglich ihrer internen Konsistenz auf ($\alpha > 0,7$). Darüber hinaus befinden sich die Mittelwerte der Skalen „Competence“, „Flow“ sowie „Positive Affect“ deutlich über dem Skalenmittelpunkt (Mittelpunkt = 2), was auf eine Zustimmung in diesen Bereichen hindeutet. Die Spieler hatten also tendenziell ein hohes Kompetenzerleben, befanden sich während des Spielens im Flow-Zustand und waren dem Spiel gegenüber positiv eingestellt. Um einen ersten Einblick in die Zusammenhänge zwischen den verschiedenen Skalen zu erhalten, werden die bivariaten Korrelationen zwischen den Skalen zur Spielerfahrung in Tab. 2 dargestellt.

Tabelle 2: Bivariate Korrelationen zwischen Skalen zur Spielerfahrung (*p < 0,05;**p < 0,01)

Skala	Competence	Immersion	Flow	Tension/Annoyance	Challenge	Negative Affect	Positive Affect
Competence	1	0,33	0,23	-0,63**	-0,04	-0,31	0,6**
Immersion	0,33	1	0,47*	0,24	0,66**	-0,43	0,72**
Flow	0,23	0,47*	1	-0,01	0,39	-0,7**	0,65**
Tension/ Annoyance	-0,63**	0,24	-0,01	1	0,47*	0,36	-0,31
Challenge	-0,04	0,66**	0,39	0,47*	1	-0,16	0,38
Negative Affect	-0,31	-0,43	-0,7**	0,36	-0,16	1	-0,7**
Positive Affect	0,6**	0,72**	0,65**	-0,31	0,38	-0,7**	1

Die bivariaten Korrelationen zwischen den Skalen zur Spielerfahrung sind für einige Skalen statistisch hoch signifikant. Dies legt einen Zusammenhang zwischen der empfundenen Herausforderung und der Immersion während des Spiels sowie mehrere Zusammenhänge mit der positiven Einstellung gegenüber dem Spiel nahe. So hängen das Kompetenzerleben, die Immersion sowie das Erleben eines Flow-Zustands mit der positiven Einstellung gegenüber dem Spiel zusammen. Eine mögliche Erklärung hierfür ist, dass die genannten Empfindungen während des Spielens zu einem positiven Gesamteindruck führen, was sich mit den Aussagen der Literatur in diesem Bereich deckt. Somit könnte die empfundene Herausforderung im Spiel indirekt den positiven Gesamteindruck erhöhen, indem sie die Immersion verstärkt.

Die qualitativen Rückmeldungen, welche Gestaltungsrichtlinien zur Informationsvisualisierung in den verschiedenen Minispielen erkannt wurden, sind in Tab. 3 dargestellt. Dabei wird zwischen korrekt erkannter Richtlinie, korrekt erkannter Problematik und nicht erkannter Richtlinie/Problematik unterschieden.

Tabelle 3: Erkannte Richtlinien und Problematiken

	Zahlen-schießen	**Flächen-gewichtheben**	**Manager-boxen**	**Säulen-hochsprung**
Richtlinie erkannt	6	4	1	2
Problematik erkannt	6	9	8	4
Richtlinie oder Problematik erkannt	12	13	9	6
Nichts erkannt	7	6	10	13

Wie Tab. 3 zeigt, konnten die Teilnehmer nur in wenigen Fällen die konkreten Gestaltungsrichtlinien identifizieren. Da diese allerdings nicht explizit im Spieldurchlauf adressiert wurden, lässt sich hieraus lediglich eine Aussage über das Vorwissen der Teilnehmer ableiten. Die in den Spielen dargestellten Problematiken (wie bspw. eine schwere Vergleichbarkeit von Flächen) konnten Teilnehmer dagegen häufiger erkennen. In den Minispielen Zahlenschießen und Flächengewichtheben wurden Richtlinien und Problematiken häufiger richtig erkannt als in den Minispielen Managerboxen und Säulenhochsprung. Dies deutet darauf hin, dass mit den ersten beiden Minispielen die angestrebten Botschaften deutlicher vermittelt werden als mit den letzten beiden Minispielen.

Neben den qualitativen Rückmeldungen zu den Gestaltungsrichtlinien wurden die Teilnehmer um Verbesserungsvorschläge für die einzelnen Minispiele gebeten. Hierbei hat sich gezeigt, dass im Minispiel Zahlenschießen noch ein höherer Schwierigkeitsgrad

gewünscht war (durch mehr Zeitdruck oder mehr dargestellte Zahlen). Darüber hinaus regten die Teilnehmer an, noch mehr Minispiele hinzuzufügen.
Insgesamt zeigt die erste Evaluation des Spiels, dass dieses zu Spaß und positiven Gefühlen sowie zusätzlich zu einem hohen Kompetenzerleben sowie einem Flow-Zustand während des Spielens führt. Darüber hinaus weist der eingesetzte Fragebogen eine hohe Reliabilität auf und kann daher nach Anpassung der Skala „Tension/Annoyance“ auch für zukünftige Evaluationen des Spiels eingesetzt werden. Durch die qualitative Rückmeldung wird ersichtlich, dass Gestaltungsrichtlinien zur Informationsvisualisierung sowie damit verbundene Problematiken zum Teil bereits während des Spielens erkannt werden. Bei dem späteren Einsatz des Spiels werden diese in einem Debriefing explizit angesprochen, was die Lernergebnisse sicherstellen soll.

2.8.7 Limitationen und Ausblick

Der in diesem Beitrag vorgestellte Prototyp stellt einen Zwischenschritt auf dem Weg zum Serious Game „Dashboard Tournament“ dar (Grund & Schelkle, 2016). Bislang können Spieler lediglich gegen fiktive Charaktere antreten. Die zukünftige Entwicklung fokussiert daher den für das Spiel wesentlichen Mehrspielermodus, bei dem Spieler auch gegeneinander antreten können. Eine erste Evaluation hat bereits positive Ergebnisse hervorgebracht, jedoch gilt es nach Fertigstellung des Spiels eine umfangreiche, experimentelle Studie zur Wirksamkeit des Spiels durchzuführen. Dieses soll insbesondere mit herkömmlichen Lehrmethoden, wie bspw. Vorträgen, verglichen werden. Wenn diese Evaluation positive Ergebnisse hervorbringt, soll das Spiel auch in der Unternehmenspraxis erprobt und evaluiert werden.

Eine Limitation des entwickelten Ansatzes ist die eventuell geringe Akzeptanz unter spielaversen Fach- und Führungskräften. Da insbesondere im deutschsprachigen Raum das spielerische Lernen im Management-Bereich noch nicht weit verbreitet ist (mmb Institut, 2016), könnte ein Spiel für diese als nicht ernsthaft missverstanden werden. Außerdem ergeben sich aus dem eingesetzten Wettbewerb u.U. Herausforderungen: So könnten sich Mitspieler mit geringen Punktzahlen gegenüber ihren Kollegen bloßgestellt fühlen. Ein Lösungsansatz hierfür ist, jeden Spieler einen Namen auswählen zu lassen und so die Möglichkeit für Anonymität zu schaffen. Insbesondere jüngeren Führungskräften, die als Digital Natives an den Umgang mit Videospielen gewöhnt sind, bietet das Dashboard Tournament jedoch eine erfahrungsbasierte und damit effektive Möglichkeit, ihre Fertigkeiten bei der Informationsvisualisierung zu verbessern.

2.9 Essay: Developing Serious Games with Integrated Debriefing: Findings from a Business Intelligence Context

Authors:	Christian Karl Grund Michael Schelkle Professur für Wirtschaftsinformatik und Management Support Universitätsstraße 16, 86159 Augsburg christian.grund@wiwi.uni-augsburg.de michael.schelkle@wiwi.uni-augsburg.de
Re-submitted after first review:	Business & Information Systems Engineering

2.9.1 Abstract

Serious games (SG) are recognized in several domains as a promising instructional approach. When it comes to the field of Information Systems (IS), however, they are not yet broadly investigated. Especially in business intelligence & analytics (BI&A), our literature review indicates the absence of SG for proper report design. Such games, however, seem beneficial since many business reports suffer from poor business information visualization (BIV). To address this issue, the scope of this study is twofold: First, we present a SG that aims to foster learning about BIV. Second, we evaluate this SG in a laboratory experiment, comparing it to a more conventional instructional approach (i.e., presentation) and testing two different versions of the game: One version integrates debriefing into the game itself, whereas the other version uses classical post-hoc debriefing. Results indicate that it is favorable to integrate debriefing into the game in terms of motivation and learning outcomes. In the vein of design science research, we thus intend to contribute a useful artifact as well as a novel design principle for this instructional approach: Integrating debriefing into SG.

2.9.2 Introduction

Serious games (SG) are recognized in several domains as a promising instructional approach (Connolly et al., 2012). Examples include health care (Basole, Bodner, & Rouse, 2013), computer science (Papastergiou, 2009), and business (Faria et al., 2009). Among the desired and often realized outcomes of these games are increased motivation and learning (Connolly et al., 2012; Grund, 2015; Wouters et al., 2009). Despite its popularity in other domains, the field of information systems (IS) has not yet broadly investigated this instructional approach, although technology-related learning plays an important role for instance in digital transformation processes in organizations (Legner et al., 2017; Matt, Hess, & Benlian, 2015). While there are some studies about SG in the field of IS, they are seemingly not yet discussed in publications following the Design Science Research (DSR) paradigm (Grund & Meier, 2016). Hence, there is still a major opportunity for the field of IS to gain insights about how to design effective SG that help organizations to train their employees in IS-related skills.

One of the most prominent IS-related capabilities for future employees is handling the ever increasing amount of information (Chen, Chiang, Roger H. L., & Storey, 2012). This includes analytical skills, business and domain knowledge as well as communication skills (Chen et al., 2012). Especially the latter often seems to be not prominently investigated in the domain of business intelligence & analytics (BI&A). This domain instead focuses mostly on analytical aspects like how to mine big data and not how the resulting findings are best presented to target audiences (Chen et al., 2012). Not surprisingly, many business reports (i.e., where results are communicated) suffer from poor business information visualization (BIV) (Beattie & Jones, 2008). Since decision makers relying on these flawed reports may be misled, it appears beneficial to develop SG with this focus to equip employees with appropriate reporting skills. Although the BI&A domain already provides some studies about SG, none of these games focus on report design and BIV yet (Grund & Meier, 2016).

To fill this gap, we set out to develop a SG that aims to increase BIV capabilities (namely being able to identify inadequate BIV and being able to suggest reasonable improvements) among players by letting them compete across several minigames (Grund & Schelkle, 2016). Each minigame confronts players with insufficient BIV, which they are supposed to avoid when designing reports. While prior research focused mainly on describing the development and architecture of this SG (Grund et al., 2017; Grund & Schelkle, 2016), the current study emphasizes its thorough evaluation. In particular, we are interested in the differences between learners playing our SG, and learners in a more conventional training condition (i.e., a presentation about the same BIV guidelines). Hence, we pose our first research question:

RQ1: Which effects on motivation and learning outcomes has using serious games for business information visualization compared to presentations?

One of the most important concerns of DSR is to generate knowledge about how an artifact is best designed to fulfill its purpose, which often includes designing different alternatives of an artifact (Hevner et al., 2004). For the development of SG, there are several possible design choices that may be investigated, including which game elements to use (Blohm & Leimeister, 2013), how to connect educational content with game content (Charsky, 2010) as well as how to facilitate the reflection on experiences after the game (Lederman, 1992). This last design aspect, which is often referred to as "debriefing", is considered an essential part of any SG, where instructors discuss the learning content of the game after the experience to ensure learning outcomes (Garris et al., 2002). Many scholars even consider this the most crucial part of SG (Crookall, 1992; Lederman, 1992), since experiential learning has to be accompanied by appropriate learner support for effective learning to happen (Garris et al., 2002; Kolb, 1984). Despite its importance for learning in SG, this design aspect is often not prominently investigated or even ignored by SG scholars (Crookall, 2010). In addition, the conventional approach of conducting debriefing after the game experience may be costly and time-consuming, since it requires participants of SG to be spatially and/or temporally synchronized with an instructor or so-called "debriefer" (Lederman, 1992). To overcome this drawback, integrating the debriefing into the game itself may be a viable solution. However, prior research has thus far not directly compared integrating debriefing into the game with conducting it in an often advocated post-hoc manner. We therefore pose our second research question to investigate this design principle:

RQ2: Which effects on motivation and learning outcomes has integrated debriefing in comparison to post-hoc debriefing as a design principle for Serious Games?

To address these research questions, we developed a SG for BIV and evaluated it in a multivariate 1x3 between-group laboratory experiment at a German University. Two groups played different versions of the game and one group was attending a presentation about the same learning content, which represented a more conventional training method. In this paper, we present and discuss the results of this experimental evaluation. Hence, this article is structured as follows: First, we describe our terminology and related work in section 2.9.3. Second, the theoretical background alongside hypotheses for the evaluation are presented in section 2.9.4. Section 2.9.5 provides a brief description of the developed artifact which is evaluated in section 2.9.6. The paper closes with a discussion and conclusion as well as an outlook on future research in sections 2.9.7 and 2.9.8.

2.9.3 Terminology and Related Work

In the following, we describe the terminology as well as related work for both SG that foster BIV skills and debriefing in SG.

2.9.3.1 Serious Games for Business Information Visualization

To investigate whether there are similar approaches to our proposed SG, we aim to characterize the state of the art of BIV as a learning goal or a learning outcome in SG. In this context, information visualization is defined as using computer-supported, interactive graphical representations of abstract data to amplify cognition (Card et al., 1999). When information visualization technologies are used to depict business information (e.g., with tables or column charts) it is referred to as BIV (Tegarden, 1999). SG may be characterized as games that have an "explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (Abt, 1987). In our case, we thus intend to identify SG that incorporate BIV capabilities as their educational purpose.

In a basic overview of SG, Susi et al. (2007) find that communication skills (i.e., effectively presenting ideas when speaking, writing, etc.) are important for employees in corporations. Although this might include BIV, this learning goal is not explicitly stated. Connolly et al. (2012) investigate empirical evidence on the learning outcomes of computer games and SG in a systematic literature review. Out of the 129 publications they identified, 17 higher quality studies report knowledge acquisition and content understanding outcomes. However, none of these studies mention BIV as a learning outcome. Another literature review about the learning outcomes of SG conducted by Wouters et al. (2009) concludes that cognitive learning outcomes (i.e., knowledge and cognitive skills) can be observed in 12 out of the 28 empirical studies investigated. Although they argue that SG seem to be effective when it comes to cognitive learning outcomes, BIV was again not a learning goal in any of the studies. In a recent literature review about using SG to improve the decision process, Grund and Meier (2016) show that BIV is not addressed in their sample of SG that include business reporting. In summary, according to the investigations mentioned above, SG that specifically focus on improving BIV skills seem to be still missing. We intend to fill this gap with the SG described in section 2.9.5.

2.9.3.2 Debriefing in Serious Games

As mentioned above, debriefing plays a crucial role when it comes to SG. In an experiential learning context, debriefing may be defined as a process that allows participants to process meaningful experiences that happened during an activity, thus facilitating learning (Lederman, 1992). It is important to note that in this definition, debriefing takes place after learners have engaged in a learning activity, often in a guided discussion. This is also reflected in prior research on debriefing in SG.

In a special issue in 1992, the journal Simulation & Gaming called for research articles focusing on debriefing, since this topic seemed to be neglected by too many scholars (Crookall, 1992). Following this call, researchers contributed definitions of debriefing (Lederman, 1992), practical recommendations (e.g., Steinwachs, 1992), and technologies for debriefing (Thiagarajan, 1992). Ever since, research on debriefing in SG discussed how to design debriefing sessions and what makes debriefing effective (Der Sahakian et al., 2015; Kriz, 2010; Pavlov, Saeed, & Robinson, 2015; Qudrat-Ullah, 2007; Rudolph, Simon, Raemer, & Eppich, 2008). In an effort to provide a structure for the reflection phase in debriefing, Kriz (2010) lays out several parameters that may be taken into account, including the role of debriefers, the use of media, oral vs. written debriefing, etc. However, whether debriefing is integrated into the activity is not among these parameters. Instead, he only mentions that when the game is too lengthy, several small rounds of debriefing may be performed after each game round. This is, however, not an integration of the reflection into the game itself as debriefing and the gaming activity are still separated. Rudolph et al. (2008) propose that debriefing might be conducted as formative assessment. In contrast to summative assessment, where feedback is given after the activity, formative assessment immediately addresses shortcomings of participants (Rudolph et al., 2008). Although this approach seems similar to integrating debriefing into the learning activity, it focuses on giving feedback to increase participants' performance during the activity, rather than fostering reflection about the meaning of the activity. The literature reviewed above shows that while the importance of debriefing is undisputed in the field of SG, studies explicitly investigating the differences between integrated debriefing and post-hoc debriefing seem to remain elusive. Hence, we examine this matter by utilizing two different versions of our SG. To lay out our reasoning as to why we expect differences between these two approaches, the theoretical background of this study is described below.

2.9.4 Theoretical Background and Hypothesis Development

Since SG are concerned with improving player capabilities as well as providing an entertaining experience, both learning and motivation theories are used in literature to explain the benefits of SG (Grund, 2015; Ryan et al., 2006; Wu, Hsiao, Wu, Lin, & Huang, 2012). To explain the motivational effects of our SG, we draw on self-determination theory (Deci & Ryan, 1985). One of its central assumptions is that intrinsic motivation (i.e., when individuals engage in behavior for the pleasure and satisfaction that they inherently experience with participation (Deci & Ryan, 1985)) requires the satisfaction of three basic psychological needs: Competence, relatedness, and autonomy. Findings in the context of self-determination theory show that video games in general foster intrinsic motivation by fulfilling these needs (Ryan et al., 2006). In our case, perceived competence may be fostered by players succeeding in the different minigames and earning points for doing so. Since players in a competition are unlikely to form meaningful social bonds, relatedness as it is described in self-determination theory may not directly be established by our SG. However, by having players compete with each other and using a leaderboard that allows for comparisons with other players, they might get a feeling of each other’s social presence, which may be regarded a prerequisite for relatedness. Last, a sense of autonomy may be achieved by players being able to choose their own approaches of how to succeed in the minigames. In contrast, participants who only attend a presentation are not expected to experience competence, since they are only passively consuming (i.e., not receiving any performance feedback). Furthermore, we expect participants only attending a presentation to experience less social presence, because they are not supposed to interact with each other. Last, perceived autonomy is expected to be below the participants in a SG setting, since only attending a presentation does not include influencing the course of actions. Resulting from these anticipated differences, we expect that participants in any SG condition will perceive higher intrinsic motivation than participants not playing the SG, since fulfilling these psychological needs fosters intrinsic motivation (Ryan & Deci, 2000; Sheldon & Filak, 2008). Often accompanied by increased intrinsic motivation is an increase in the perceived task value (Ryan, 1982). In our case, this task value refers to whether participants deem the learning activity as important and adequate for learning about BIV. Hence, we propose that participants who play any version of the SG show increased motivational outcomes compared to participants in a presentation setting according to self-determination theory. This leads to our first group of hypotheses:

H1a: Participants who play any version of the serious game will experience higher autonomy than participants only attending a presentation.

H1b: Participants who play any version of the serious game will experience higher competence than participants only attending a presentation.

H1c: Participants who play any version of the serious game will experience higher social presence than participants only attending a presentation.

H1d: Participants who play any version of the serious game will experience higher intrinsic motivation than participants only attending a presentation.

H1e: Participants who play any version of the serious game will experience higher task value than participants only attending a presentation.

When it comes to expected differences between the two versions of our SG, the basic psychological needs described in self-determination theory may be used to provide possible explanations. As mentioned above, the first version of our SG includes debriefing during the gameplay, whereas the second version uses debriefing after the game (“post-hoc debriefing”). Hence, in both versions, players still solve the same tasks and compete identically, which is why we do not expect differences in either perceived competence or social presence. However, we do expect a difference in perceived autonomy. The reason for this is that players who receive a debriefing after the game may perceive a shift in their locus of control, meaning that they no longer control what is going on after playing. Instead, either the debriefer or a debriefing video determines all following events. In contrast, when the meaning of the exercise is presented during the game, players may still opt to simply close this description after reading it, thus still being able to control what is being displayed and for how long. Since a change in any of the psychological needs may have an impact on intrinsic motivation (Sheldon & Filak, 2008), we further expect the intrinsic motivation of the integrated debriefing group to be higher due to a higher feeling of autonomy. Again, this may also positively impact the perceived task value of the group with integrated debriefing. Hence, we derive our second group of hypotheses:

H2a: Participants who play the serious game with integrated debriefing will experience higher autonomy than participants who play the game with post-hoc debriefing.

H2b: Participants who play the serious game with integrated debriefing will experience higher intrinsic motivation than participants who play the game with post-hoc debriefing.

H2c: Participants who play the serious game with integrated debriefing will experience higher task value than participants who play the game with post-hoc debriefing.

Regarding the desired learning outcomes, prior studies suggest that participants who engage in experiential learning (e.g., playing SG) rather than only attending a presentation, show higher observed learning outcomes (Connolly et al., 2012; Wouters et al., 2009). The theoretical underpinning of this increased learning success is rooted in experiential learning theory (Kolb, 1984). Its main rationale is that individuals learn most effectively when they reflect on concrete experiences and actively experiment based on the resulting conceptualizations (Kolb, 1984). Since SG allow players to go through all stages of the so-called learning cycle, we expect participants engaging in our SG to show higher observed learning outcomes than participants only attending a presentation.

However, this is not the only reason for possible differences between the groups. The anticipated differences in intrinsic motivation may also lead to differences in observed learning outcomes, since several studies suggest a positive relationship between intrinsic motivation and learning (e.g., Kusurkar, Ten Cate, Vos, Westers, & Croiset, 2013; Taylor et al., 2014). Based on the anticipated differences in intrinsic motivation described above, we thus propose our third group of hypotheses:

H3a: Participants who play any version of the serious game will show higher learning outcomes than participants only attending a presentation.

H3b: Participants who play the serious game with integrated debriefing will show higher learning outcomes than participants who play the game with post-hoc debriefing.

To investigate these hypotheses, we will evaluate our SG after briefly describing it in the following section.

2.9.5 Artifact: Dashboard Tournament

To develop the Dashboard Tournament, we employed the human-centred design process (see Grund & Schelkle, 2016 for details). For its implementation, we used the game engine Unity with C# as its programming language. An overview of the game's technical architecture is provided by Grund et al. (2017). In the following, we briefly describe the game's educational purpose as well as its structure (for a more detailed description see Grund & Schelkle, 2016 and Grund and Schelkle (2017)).

2.9.5.1 Educational Purpose

As mentioned earlier, the Dashboard Tournament aims at improving BIV skills of players. A possible approach to improve these skills is conveying visualization guidelines that inform report design decisions. Although several guidelines for information visualization exist (e.g., Ware, 2012), only few focus on elements used specifically in business reports.

One framework that highlights the design of business reports and presentations is called International Business Communication Standards (IBCS) (Hichert & Faisst, 2015). This framework comprises specific guidelines that showcase examples of poor BIV alongside their proposed corrections. We hence incorporated these guidelines in our SG to enable players to identify inadequate BIV and to suggest reasonable improvements. These two skills, namely being able to identify inadequate BIV and being able to suggest reasonable improvements, are what we refer to as BIV skills in this study. The specific guidelines included in our SG are described in the following alongside the structure of the game.

2.9.5.2 Game Structure

The Dashboard Tournament is a multiplayer SG featuring a competition across four minigames (Grund & Schelkle, 2016). Each minigame addresses one specific guideline for adequate BIV from different perceptual IBCS rule sets (Hichert & Faisst, 2015). An overview of the minigames implemented in the Dashboard Tournament is provided in Figure 1.

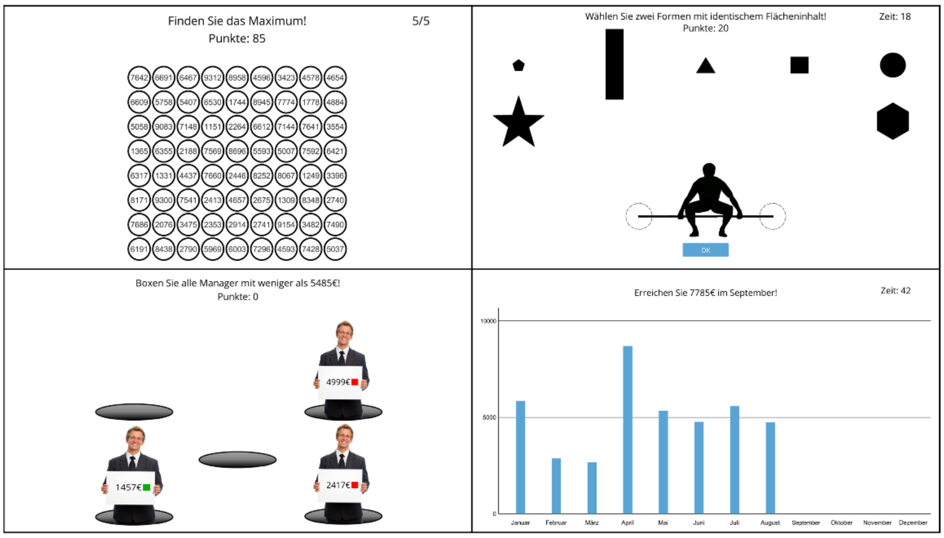

Figure 1: Minigames implemented in the Dashboard Tournament
(Screenshots from the software used in the experiment)

The first minigame (upper left image in Figure 1) addresses the guideline CO 4.4 (Hichert & Faisst, 2015). This guideline recommends using graphical elements in tables to easily identify differences in size between numbers. The basic layout of the minigame is a grid of targets with numbers (similar to a table) without graphical support. Players only have limited time to identify the maximum value. Hence, players have to compare the numeric value of every target inside the grid, which causes high cognitive effort.

In the second minigame (upper right image in Figure 1), the guideline CH 3.1 is covered (Hichert & Faisst, 2015). This guideline advises against using area comparisons in reports (which is the case for example with pie charts) and instead suggests using length comparisons. To experience the difficulty of correctly comparing area sizes, players have to select two shapes with identical areas out of several different shapes and attach them to a weightlifting bar.

The next minigame (lower left image in Figure 1) is concerned with the guideline EX 2.5 (Hichert & Faisst, 2015). This guideline disadvises from using traffic light indicators in reports, since they distract from comprehending the actual numbers. To show this effect, players have to hit all managers holding numbers below a given threshold in a "Whac-A-Mole"-style minigame. Inconsistencies between the traffic light colors and the numbers lead to wrong decisions when players blindly trust the traffic light indicators.

The last minigame (lower right image in Figure 1) addresses the guideline SI 3.1 (Hichert & Faisst, 2015). This guideline recommends replacing value axes in column charts with data labels. Players are given a target value and hold a key to "grow" a column with the corresponding height. In doing so, players experience difficulties when estimating the exact height given only a value axis and gridlines.

The experienced difficulties in all four minigames lay the foundation for debriefing, where experiences may be reflected upon (Lederman, 1992). As mentioned in section 2.9.3, literature in the domain of SG suggests conducting a debriefing session after the learning activity took place (i.e., after all minigames are completed). To investigate the differences between this approach and integrating debriefing into the game itself, we developed two versions of the game: The first version shows participants the corresponding IBCS guideline after each minigame, explaining why several kinds of BIV should be avoided in business reports (“integrated debriefing”). In the second version, these explanations are missing and participants only play the minigames. Therefore, in the second version of the game, a conventional debriefing is required after the game for learning to take place (“post-hoc debriefing”). These two versions of the game are used in the experimental evaluation of our artifact which is described below.

2.9.6 Evaluation

To evaluate our artifact, we conducted a laboratory experiment. In the following, we describe the study setup, the development of the measurement instrument, as well as the results of this experimental evaluation.

2.9.6.1 Method, Participants, and Design

Following the DSR paradigm, this study aims to evaluate our developed artifact in order to generate design knowledge (Hevner et al., 2004). The purpose of this evaluation is twofold: First, we aim to evaluate an instantiation of our designed artifact to establish its utility and efficacy for achieving its stated purpose (Venable et al., 2012), namely increasing motivation and learning. Second, we intend to evaluate our designed artifact in comparison to other designed artifacts’ ability to achieve a similar purpose (Venable et al., 2012), as we seek to compare our SG featuring integrated debriefing with our SG using post-hoc debriefing. Since an artificial evaluation environment provides the benefit of controlling for possibly confounding circumstances and since the artifact has already been developed (“ex post evaluation”), we chose to conduct a laboratory experiment using a multivariate 1x3 between-group design, as suggested by Venable et al. (2012). Participants were recruited at a German University and comprised different fields of study. Since our SG is supposed to be used in higher education as well as in industry, this sample reflects both current students as well as prospective junior managers and report designers. In addition, since our SG targets laypersons in report design and since BIV is relevant in many professional domains, the sample was not limited to business students. Every participant received a monetary compensation for being included in the study. The demographics of participants are depicted in Table 1, grouped by the treatments described in the following.

Table 1: Demographics

		Group 1	Group 2	Group 3	Total
Gender	Male	7 (37%)	10 (59%)	9 (56%)	26 (50%)
	Female	12 (63%)	7 (41%)	7 (44%)	26 (50%)
Age	18-24	14 (74%)	14 (82%)	11 (69%)	39 (75%)
	25-34	5 (26%)	3 (18%)	5 (31%)	13 (25%)
Field	Business/Economics	11 (58%)	8 (47%)	8 (50%)	27 (51%)
	Industrial Engineering	3 (15%)	2 (12%)	2 (13%)	7 (13%)
	Law	2 (11%)	1 (6%)	3 (18%)	6 (12%)
	Education	2 (11%)	2 (12%)	2 (13%)	6 (12%)
	Others / Missing	1 (5%)	4 (23%)	1 (6%)	6 (12%)
Education	High School Degree	11 (58%)	12 (71%)	9 (56%)	32 (62%)
	University Degree	8 (42%)	5 (29%)	7 (44%)	20 (38%)

Participants have been randomly assigned to one of three groups: The first group played the Dashboard Tournament with integrated debriefing (i.e., corresponding guidelines were shown after each minigame). The second group played an identical game without the guidelines being shown and with a post-hoc debriefing afterwards. Last, there was a control group only attending a presentation about the same BIV guidelines. To ensure that the debriefing was delivered identically in groups 2 and 3, we used a video of a presentation as debriefing. Although literature usually suggests that debriefing should be personalized to the learners and include active discussions (Lederman, 1992), there are also findings indicating that video-assisted self-debriefing is on par with instructor-guided debriefing (Boet et al., 2011). Since competition and changing leaderboards may confound independency of observations, every participant was shown their own score alongside fictional competitor scores after playing. To assess the motivational effects of each treatment, participants in every group filled out post-experience questionnaires regarding motivational outcomes. For assessing learning outcomes, pre- and posttests addressed participants' BIV capabilities. To see whether these acquired capabilities are sustainable, posttests have been conducted one week after the treatment. A summary of this design is presented in Table 2.

Table 2: Experimental Design of the Evaluation

Group (N)	**Pretest**	**Treatment**	**Post-Experience**	**Posttest**
1 (19)	BIV skills	Integrated Debriefing	Motivation	BIV skills
2 (17)	BIV skills	Post-hoc Debriefing	Motivation	BIV skills
3 (16)	BIV skills	Presentation	Motivation	BIV skills

The measurement instrument utilized for post-experience questionnaires as well as for pre- and posttests is described in the following.

2.9.6.2 Development and Validation of the Measurement Instrument

The measurement instrument for post-experience questionnaires was mainly based on the intrinsic motivation inventory (IMI) that has been used in many studies to measure basic psychological needs as well as intrinsic motivation after an experience (Ryan, 1982). We included the subscales Interest/Enjoyment (i.e., intrinsic motivation), Competence, Autonomy, and Task Value. Changes have been made to the Autonomy subscale, which has been adjusted to express the amount of control and influence participants felt (Grund & Tulis, 2017). As described earlier, we did not measure relatedness of participants but rather social presence as a potential prerequisite for relatedness. For this, we drew from the Behavioral Engagement subscale of the "social presence in gaming questionnaire (SPGQ)" developed by de Kort, IJsselsteijn, and Poels (2007). To measure participants' overall appreciation of video games, which may arguably confound their motivational outcomes in the treatments with our SG, we used the "Usefulness, Importance, and

Interest" subscale from Wigfield and Eccles (2000). In our study, we refer to it as "Game Value", since it expresses how each participant values video games in general. All items adapted and derived from other instruments were modified to relate to the context and translated into German. Items were assessed using a 6-point scale, ranging from 1 = *not at all true* to 6 = *very true*, and were randomized across all subscales. In addition to the questionnaire items, students were provided with space for leaving any comments or suggestions.

To validate the psychometric properties of the resulting instrument and to examine the overall model fit of our measurement model, we conducted a confirmatory factor analysis. After minor modifications (e.g., correlated errors, for an overview see Brown (2015)), our measurement model reached a satisfactory model fit according to generally accepted thresholds (Hu & Bentler, 1999). The ratio between χ^2 and df was 1.23, which is below the desired ratio of 3. The root mean standard error of approximation (RMSEA) was .068 and therefore within the range of acceptable model fit of .08. Last, both comparative fit index (CFI) and Tucker-Lewis index (TLI) are above their common suggested minimum value of .90 (CFI=.92 TLI=.91). We may hence conclude that our measurement instrument achieved a satisfactory model fit. In addition, we accounted for reliability of the scales by computing Cronbach's α, which ranges from .82 to .96 and is hence above the desired minimum of .70 (Krippendorff, 2004). To account for discriminant validity, we investigated the square root of the average variance extracted (AVE) of each construct in combination with the correlations between constructs (Fornell & Larcker, 1981; Gefen & Straub, 2005). As shown in Table 3, each inter-construct correlation lies below the square root of AVE of each construct, hence discriminant validity is demonstrated.

Table 3: Square root of AVE (bold) and Inter-construct Correlations

	IMOT	COMP	AUTO	SOP	TASKV	GAMV
IMOT	**.74**					
COMP	.14	**.76**				
AUTO	.33	.12	**.80**			
SOP	-.37	-.10	.48	**.71**		
TASKV	.47	.18	.31	.09	**.80**	
GAMV	-.07	.42	.10	-.01	.08	**.88**

To ensure convergent validity, standardized factor loadings (λ) are investigated for each construct. They range from .55 to .98 and are thus above the recommended minimum of .45 for a fair rating (Tabachnick & Fidell, 2013). Overall, construct validity is shown by confirming both discriminant and convergent validity. Table 4 summarizes our measurement model in the post-experience questionnaire and shows its psychometric properties.

Table 4: Measurement Instrument (Post-Experience Questionnaire)

Factor	Item	M	SD	λ	α
Intrinsic Motivation (IMOT) (Ryan, 1982)	The session has been fun.	4.94	.85	.89	.82
	I thought the session was boring. (R)	5.21	.78	.72	
	I thought the session was quite enjoyable.	4.92	.84	.56	
	I enjoyed attending this session very much.	5.27	.66	.76	
Perceived Competence (COMP) (Ryan, 1982)	I think I was pretty good in this session.	4.08	.95	.85	.84
	I think I did pretty well in this session, compared to other students.	4.06	.94	.71	
	I am satisfied with my performance in this session.	4.63	.86	.74	
	I was pretty skilled in this session.	3.96	1.00	.71	
Perceived Autonomy (AUTO) (Grund & Tulis, 2017; Ryan, 1982)	In this session I could choose what to do.	2.19	1.21	.70	.86
	In this session I had the feeling to be able to co-determine.	1.98	1.02	.92	
	I had the feeling to be able to influence the session.	2.25	1.27	.66	
	I had the impression to be able to co-determine what happens.	2.04	1.08	.91	
Social Presence (SOP) (de Kort et al., 2007)	During the session, I felt close to the other students.	2.06	.94	.55	.86
	During the session, I sensed the presence of the other students.	2.58	1.29	.91	
	During the session, I sensed the attendance of the other students.	3.02	1.31	.76	
	During the session, I thought of the other students.	2.33	1.28	.65	
	During the session, I was wondering how the other students are doing.	3.02	1.61	.70	
	During the session, I was wondering how easy the task might be for the other students.	3.44	1.78	.63	
Task Value (TASKV) (Ryan, 1982)	I believe this session was of value to me.	4.19	1.16	.89	.91
	I think this session was well-suited for learning.	4.27	1.27	.80	
	I think this session was important to learn something about its content.	4.54	1.15	.87	
	I believe this session has helped me gain a better understanding.	4.19	1.21	.71	
	I believe that this session was beneficial to me.	4.52	1.08	.86	
	I think this session was important.	3.90	1.12	.60	
Game Value (GAMV) (Wigfield & Eccles, 2000)	Video games are interesting to me.	3.67	1.75	.98	.96
	Engaging with video games provides fun to me.	4.17	1.53	.88	
	Video games have a personal utility for me.	2.94	1.59	.87	
	Video games are beneficial to me.	2.48	1.32	.87	
	Being good at video games is important to me.	2.71	1.46	.77	
	Video games are important to me personally.	2.56	1.61	.91	

Learning outcomes have been assessed by comparing participants' initial knowledge of the IBCS guidelines included in our SG with their knowledge about these guidelines after the experiment. For this purpose, participants were provided with different examples of business reports and requested to suggest improvements. The provided reports suffered from inadequate BIV that is addressed by the guidelines covered in the different treatments. To keep participants from simply guessing, we also included obvious other mistakes that were not related to the IBCS guidelines addressed. We could hence check whether improvements suggested by participants complied with the BIV guidelines included in the treatment. If a participant did not suggest an improvement consistent with the IBCS guideline in the pretest but managed to do so in the posttest, we considered this an observed learning outcome of the participant. The flawed business reports presented to participants are shown in Figure 2.

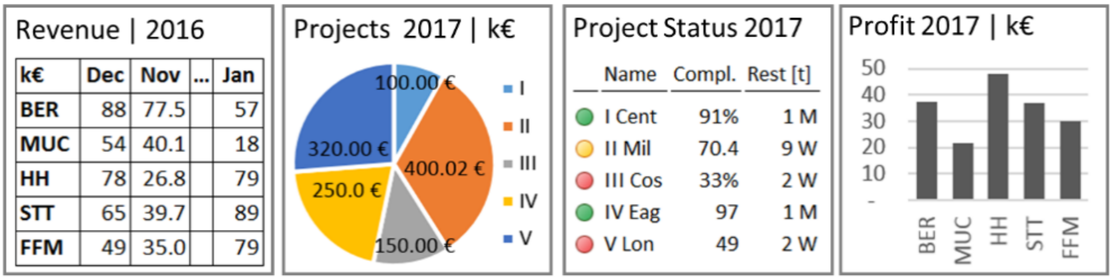

Figure 2: Flawed Business Reports (pre- and posttest of BIV skills)

2.9.6.3 Results

As a first analysis, we were interested in whether the perceived game value (GAMV) affects motivational outcomes (e.g., intrinsic motivation) among participants in SG conditions. To see potential influences of this variable, we investigated bivariate correlations between GAMV and the dependent variables in our first group of hypotheses (H1a-H1e). These correlations are presented in Table 5.

Table 5: Bivariate Correlations with the Control Variable (*p<0.05, **p<.01, ***p<.001)

	COMP	AUTO	SOP	IMOT	TASKV
GAMV (Group 1)	.69**	.17	.09	.30	.41
GAMV (Group 2)	.57*	.47	.28	-.23	-.03
GAMV (Group 1+2)	.59***	.19	.21	-.10	.19

According to Table 5, there have been significant correlations between GAMV and COMP in both groups. This seems reasonable, since individuals who value video games are more likely to have higher skills in them, thus assessing their own competence in a game-based activity as higher. However, this does not seem to influence other motivational outcomes, especially intrinsic motivation does not seem to be affected by GAMV. This might be a first indicator that aversion towards video games in general does not erode the motivational outcomes of the SG.

To investigate differences in motivation between our three experimental groups, we conducted a one-way MANCOVA with planned contrasts to test our hypotheses. This method of analysis is specifically useful when intercorrelations between dependent variables are expected (Tabachnick & Fidell, 2013), which is the case with our variables measuring different aspects of intrinsic motivation. Regarding the requirements for this analysis method, we first checked whether covariance matrices are equal among groups. This is the case, since Box's M test turned out non-significant (p=.45). Next, we used Levene's test for equality of error variances across groups, which turned out to be non-significant for all dependent variables except for perceived autonomy (p=.046). Hence, we adjusted the level of significance for this variable to p=.025 as suggested by Tabachnick and Fidell (2013). After checking for the requirements, we may proceed with our one-way MANCOVA. To account for the possible differences due to GAMV (see Table 5), we included it as a covariate in our group comparison. As dependent variables, we included all motivational outcomes described in our first group of hypotheses (H1a-H1e). The result of this analysis shows that the treatment led to significant differences between groups with Wilk's Λ=.63, p=.016, and partial η^2=.207. Our covariate, namely GAMV, also had a significant impact on group differences with Wilk's Λ=.74, p=.020, and partial η^2=.256. To investigate the nature of these differences, we used planned contrasts in line with our hypotheses.

In a first contrast analysis, we aimed at testing our first group of hypotheses (H1a-H1e), namely whether participants in any SG condition show increased motivational outcomes compared to participants in a presentation. Hence, we used simple contrasts comparing the means of the two SG groups with the control group. The results of this analysis are shown in Table 6.

Table 6: MANCOVA Results for Control Group Comparisons (*p<.05)

H	Construct	M_{G1}	M_{G2}	M_{G3}	$M_{G1} - M_{G3}$	$M_{G2} - M_{G3}$	Support
H1a	COMP	3.78	3.56	3.48	.30	.08	Not supported
H1b	AUTO	2.64	2.11	2.35	.29	-.24	Not supported
H1c	SOP	2.27	2.58	2.15	.12	.43	Not supported
H1d	IMOT	3.41	3.04	3.30	.11	-.26	Not supported
H1e	TASKV	2.88	2.82	3.32	**-.44***	**-.50***	**Supported (opposite)**

Table 6 shows that, despite theoretically expected differences, there are no significant differences in terms of intrinsic motivation (H1d) and satisfaction of basic psychological needs (H1a-H1c) between the SG conditions and the control group. Surprisingly, H1e was supported in the opposite direction, indicating that participants in the control group found the presentation more important and appropriate for learning. Regarding our control variable GAMV, there was a significant impact on COMP (p<.001, partial η^2=.232). In other words, participants who valued games higher, felt higher competence.

To test our second group of hypotheses, a simple contrast between the two SG groups was used to investigate mean differences. Table 7 shows the results of this analysis.

Table 7: MANCOVA Results for Comparisons between SG Groups (*p<.05)

H	Construct	M_{G1}	M_{G2}	$M_{G1} - M_{G2}$	Support
H2a	AUTO	2.64	2.11	.53	Not supported
H2b	IMOT	3.41	3.04	**.37***	**Supported**
H2c	TASKV	2.88	2.82	.06	Not supported

Although perceived autonomy did not differ significantly between the two groups, the group with integrated debriefing reported significantly higher intrinsic motivation. This is interesting, since there is no significant difference in any of intrinsic motivation's antecedents proposed by self-determination theory. In addition, there was no significant difference in perceived task value.

Regarding the learning outcomes, we were interested in whether participants were able to increase their knowledge about BIV guidelines in each group. As described earlier, an observed learning outcome shows when participants were not able to make a suggestion in accordance with the IBCS guideline in the pretest, but were able to do so in the posttest. Since this kind of comparison is essentially a within-subject analysis, we used dependent t-tests to observe increases in BIV knowledge for each group. Table 8 shows the results of this analysis.

Table 8: Learning Outcomes per Group (*p<.05, **p<.01, ***p<.001)

	Integrated Debriefing (N=19)			**Post-hoc Debriefing (N=17)**			**Control Group (N=16)**		
Guideline	M_{PRE}	M_{POST}	ΔM	M_{PRE}	M_{POST}	ΔM	M_{PRE}	M_{POST}	ΔM
CO 4.4	.32	.68	**.37****	.12	.53	**.41****	.44	.56	.12
CH 3.1	.16	.63	**.47****	.24	.35	.12	.19	.69	**.50****
EX 2.5	.05	.42	**.37***	.00	.35	**.35****	.06	.75	**.69*****
SI 3.1	.26	.74	**.47****	.24	.41	.17	.13	.69	**.56****

As can be seen in Table 8, participants who played the SG with integrated debriefing were able to significantly increase their knowledge about all four BIV guidelines. For instance, 32% of the participants in this group were already familiar with the guideline CO 4.4 in the pretest. In the posttest, 68% of the participants were able to make the correct suggestion. This increase of 37 percentage points was statistically significant at the $p<.01$ level. Looking at the learning outcomes in the SG group with post-hoc debriefing, we find that only knowledge about half of the guidelines presented could be significantly increased (namely CO 4.4 and EX 2.5). Last, in the control group, knowledge about three out of the four guidelines could be significantly increased. These findings indicate that integrating debriefing into SG may yield the highest learning outcomes. Using SG with post-hoc debriefing, however, seems to be even inferior to conventional presentations. This means that, with regard to hypothesis H3a, we did not find support that using any version of our SG yields higher learning outcomes than providing only a presentation: It is important how the debriefing is integrated into the learning activity. Regarding hypothesis H3b, we found that integrating debriefing into the SG seems superior to conducting it in a classical post-hoc manner, since knowledge about twice as many guidelines could be significantly increased.

Regarding participants' comments on their experiences, we conducted a summative qualitative content analysis (Hsieh & Shannon, 2005). We investigated two different open questions: First, what did participants like about the session? And second, what should be changed about the session? Answers were manually assigned to categories by the authors in a consensual procedure for each of the SG groups. Only comments about the SG and debriefing were analyzed (not, for instance, comments on the questionnaires used). Table 9 shows which aspects have been mentioned by participants.

Table 9: Results of the Summative Qualitative Content Analysis

Group	Participants liked	#	Participants wished for	#
Integrated Debriefing	Debriefing	7	Longer game	1
	Game overall	5	Longer tutorials	1
	Competition	2	More precise tutorials	1
	Tutorials	2	Less waiting time	1
	Interactivity	1	More comparisons	1
	Feeling of success	1	Longer display of results	1
	Variety	1		
Post-hoc Debriefing	Game overall	8	Better video quality	1
	Debriefing	2	Less waiting time	1
	Variety	2	Slower presentation	1
	Competition	1		
	Interactivity	1		
	Tutorials	1		

As can be seen in Table 9, participants in the SG group with integrated debriefing most often mentioned the debriefing as their favorite part of the game, followed by statements that referred to the game itself as a positive experience (without further differentiation). In the group with post-hoc debriefing, however, debriefing was only mentioned by two participants as something they liked about the session. In this group, the game itself received the most positive remarks. This indicates that debriefing was more popular in the group with integrated debriefing. The game overall, however, was apparently appreciated in both groups. Recommendations for improving the game are scattered and span from longer gameplay to improved instructions in the game (i.e., tutorials). They do not indicate a single major issue with the game in both groups. These and other aspects of our results will be discussed in the following section.

2.9.7 Discussion

Looking at the results described above, there are several unexpected findings. First and foremost, contrary to what we expected, we found no differences in intrinsic motivation and satisfaction of basic psychological needs in the SG groups compared to the group only attending a presentation. Although particularly the group with integrated debriefing showed higher means in these variables, none of these differences turned out to be significant. In addition, the control group reported significantly higher task value than both SG groups. In other words, participants attending a presentation rated it more appropriate for learning about BIV guidelines than both SG groups. A possible explanation for this might be that students are used to presentations as a prevalent method of knowledge distribution. Hence, when they attend an apparently interesting presentation, they rate it as highly appropriate for learning. In contrast, students are usually not used to play games for learning, they may thus be more hesitant to rate them as a very useful activity. Regarding the lack of motivational differences, the effect size of using SG on the basic psychological needs as well as intrinsic motivation may be too small for the present sample size in this study. The effect size of integrating debriefing versus conducting it in a post-hoc manner, however, seems to be higher. This is shown by a significant difference in intrinsic motivation between these two groups. Participants who played our SG with integrated debriefing enjoyed the experience more than participants who played it with post-hoc debriefing. Interestingly, however, this difference may not be explained with the hypothesized difference in perceived autonomy, since it did not turn out to be significant. This finding, alongside the lack of significant differences in satisfaction of basic psychological needs between the SG groups and the control group, may indicate that an additional theoretical lens for describing motivational differences might be beneficial in future studies.

Differences in learning outcomes show that integrating debriefing into SG may not only lead to higher intrinsic motivation, but also to increased learning outcomes. More specifically, participants who played the game with integrated debriefing were able to significantly increase their knowledge about twice as many BIV guidelines compared to participants in the post-hoc debriefing group. This is in line with our expectation that increased motivation in the integrated debriefing group may foster learning outcomes. When compared to the control group, participants in the integrated debriefing group showed slightly higher learning outcomes and participants in the post-hoc debriefing group showed slightly lower learning outcomes. This may indicate that when using SG with post-hoc debriefing, participants may actually learn less than in a regular presentation. A possible reason for this is the temporal proximity of reflection on the activity. While participants in the integrated debriefing group are asked to reflect about each minigame immediately after they played it, participants with post-hoc debriefing are forced to remember their experiences in each minigame. Although this does not seem like a daunting task, given that only four minigames are played, this form of debriefing apparently leads to less learning. Interestingly, although participants in the control group deemed the session as more important and appropriate for learning, they seem to have fewer learning outcomes than participants in the integrated debriefing group. This indicates that while SG seem to be able to increase learning outcomes compared to conventional training methods, they are not yet recognized as “serious” enough. Regarding the qualitative comments of participants, we also find support for integrating debriefing into SG. While most participants in the group with integrated debriefing mentioned this very debriefing as a positive aspect of the session, only two participants in the group with post-hoc debriefing explicitly mentioned the debriefing as something they liked. However, they did mention the game overall as a positive aspect of the session, indicating that when integrating debriefing into the game, it is perceived as a part of the game instead of a separated learning activity, which may also explain its higher success in fostering learning outcomes.

Regarding the findings discussed above, this study provides several contributions customary to DSR (Briggs & Schwabe, 2011). The first mode of inquiry we employed is applied research and engineering, which leads to instances of generalizable solutions, proof-of-concept prototypes, and evidence that solutions are useful and generalizable (Briggs & Schwabe, 2011). In our case, we developed and evaluated the (according to our literature review) first SG about BIV, thus contributing a novel artifact to the domain of BI&A. In a laboratory experiment, we showed that this SG is useful for increasing knowledge about BIV guidelines and is appreciated by participants judging by their qualitative comments. When compared to a more conventional instructional approach (i.e., a presentation), we did not find significant differences in motivation from the theoretical lens of self-determination theory. However, providing the SG with integrated debriefing indicates higher learning outcomes than a conventional presentation. Concerning our first research question (i.e., "*Which effects on motivation and learning outcomes has using Serious Games for Business Information Visualization compared to more conventional presentations?*"), we may thus conclude that while not necessarily leading to increased motivation, SG may improve learning outcomes compared to conventional training methods. Regarding the generalizability of these findings, it is important to note that the presentation in the control group was not varied (i.e., we only investigated one specific presentation). To thoroughly compare SG with conventional training methods, we also must alter different aspects of presentations (e.g., length or quality of visual support). This is an opportunity for future research, as we are unlikely to ever conclude that one way of instruction is superior to another, but rather that different designs of each instructional approach lead to different effects and outcomes.

The second mode of inquiry leading to DSR contributions used in this study is experimental research (Briggs & Schwabe, 2011). This mode of inquiry leads to hypotheses, experimental designs, and analyzed data sets (Briggs & Schwabe, 2011). With these contributions, DSR aims to measure the degree to which design objectives have been achieved. In this study, hypotheses have been derived from self-determination theory, which served as the kernel theory for artifact construction. As an important contribution, we developed a measurement instrument that may be used in future studies about SG in the IS domain. Using this measurement instrument, we were able to show that one of the most important dependent variables, namely intrinsic motivation, significantly differed between the groups with integrated and post-hoc debriefing. In addition, learning outcomes seem to be higher when debriefing is integrated into the SG. Being the (according to our literature review) first study that deliberately investigates the differences between integrated and post-hoc debriefing by implementing two different versions of a SG, we contributed to the design of effective SG. Thus, with regard to our second research question (i.e., "*Which effects on motivation and learning outcomes has integrated debriefing in comparison to post-hoc debriefing as a design principle for*

Serious Games?”), we may conclude that integrating debriefing into SG may yield beneficial outcomes in terms of learning and motivation compared to post-hoc debriefing, thus being a promising design principle for SG. One limitation of this finding might be the way that debriefing was conducted in the group with post-hoc debriefing. Although there are studies indicating that video-assisted self-debriefing is on par with discussion-based debriefing with an instructor (Boet et al., 2011), this was not investigated in this study. Hence, future research should deliberately examine whether our findings about integrated debriefing may be replicated when compared to discussion-based post-hoc debriefing.

2.9.8 Conclusion

This study set out to evaluate a SG about BIV, which likely constitutes a novel artifact in the domain of BI&A. In addition, we investigated the role of integrated debriefing in SG, which has thus far not been deliberately examined. Our findings indicate that SG are able to increase BIV skills and are acknowledged by participants. We also found that integrating debriefing into SG may yield significant benefits: It leads to higher motivation and learning outcomes compared to SG with post-hoc debriefing. This might be an important finding, especially since SG still heavily rely on this post-hoc debriefing. In addition, findings indicate that SG with integrated debriefing may enhance learning compared to conventional presentations. SG with post-hoc debriefing, however, seem inferior to these presentations. We thus found evidence that simply using SG will not necessarily increase learning and motivation compared to conventional training methods. Instead, it is important to thoroughly investigate design principles for SG in order to harness their potential. This study hence invites the field of IS to examine SG in the tradition of DSR in future studies. This may not only lead to increased design knowledge about SG, but also help to support ongoing learning processes in organizations facing the challenges of digital transformation.

3 Conclusion and Outlook

During the course of this dissertation's projects, we developed three software artifacts, the "BIV Assistant", the "BIV Learning Assistant", and the "Dashboard Tournament" to address the problem of unsatisfying compliance with BIV guidelines due to either insufficient software support or lack of BIV education. Referring to Gregor and Hevner (2013), we hence contribute to research by providing "improvements" since we developed new solutions for known problems (Gregor & Hevner, 2013). In particular, we contribute to IS research by providing insights on how software artifacts can affect compliance with guidelines as well as learning guidelines in a BIV context. A framework that may be used to further categorize DSR contributions is introduced by Briggs and Schwabe (2011), who distinguish different modes of inquiry (e.g., Exploratory Research, Experimental Research, or Applied Research and Engineering) to achieve scientific contributions (see Figure 6).

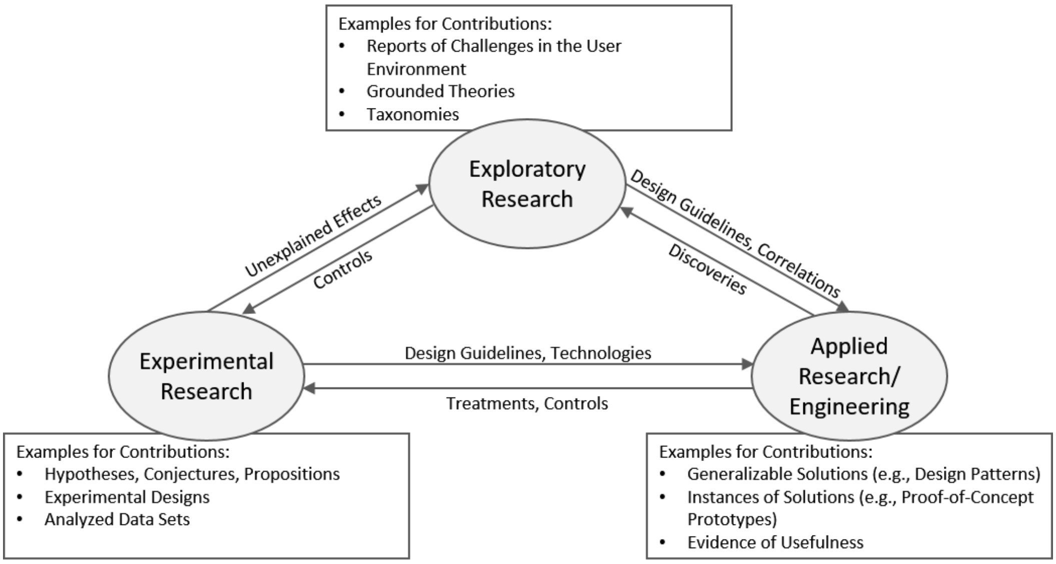

Figure 6: DSR Contributions (adapted from Briggs & Schwabe, 2011)

Exploratory Research encompasses the discovery and description of unexplained phenomena, their correlates, and the contexts in which they manifest. One may contribute to DSR by reports of challenges in the user environment (Briggs & Schwabe, 2011). These may be classified in taxonomies and synthesized grounded theories (Briggs & Schwabe, 2011). The objective of *experimental research* is to test propositions of a theoretical background and hence contribute to DSR by providing hypotheses, experimental designs, and analyzed data sets (Briggs & Schwabe, 2011). *Applied Research and Engineering* aims at using scientific knowledge to solve important practical problems and contributes to DSR for instance with generalizable solutions for a class of problems (e.g., design patterns), instances of solutions (e.g., reference models, or proof-of-concept prototypes), or evidence that solutions are useful and generalizable (Briggs & Schwabe, 2011). In the following, we use this framework to categorize the dissertation's research contributions in more detail. Please refer to Figure 7 for a first overview of the dissertation's key contributions categorized by project and modes of inquiry.

	User Assistance Systems		Serious Games
	Compliance with BIV Guidelines	Learning BIV Guidelines	
	Project BIV Assistant	**Project BIV Learning Assistant**	**Project Dashboard Tournament**
Exploratory Research	Prior literature has scarcely discussed: 1. UAS that reveal & amend misleading graphics based on BIV guidelines. 2. Design features for UAS regarding PEOU, PU. 3. Do UAS foster the intention to comply with guidelines?	UAS for feedback-based learning, in particular for learning BIV guidelines is a novelty in the field of IS.	SG that emphasize on BIV are not yet prominently discussed in prior literature.
Applied Research/ Engineering	First prototypical UAS called the "BIV Assistant" is developed in a SAP UI5 environment.	First UAS prototype called "BIV Learning Assistant" is developed as Microsoft Excel Add In to convey BIV knowledge in workplace learning. • 1st version - 4 BIV guidelines. • 2nd version - 8 BIV guidelines for various chart types.	First SG called "Dashboard Tournament " for conveying BIV knowledge is developed with the game engine Unity.
Experimental Research	Important design features: 1. PU: error reduction, sufficient explanations, transparent changes. 2. PEOU: easy to understand explanations, multilingualism. PEOU is especially important to foster the intention to comply with guidelines.	1. Students applying UAS that assist in learning, have significantly higher learning outcomes compared to students using more conventional means of learning assistance. 2. UAS may lead to a significant increase in BIV knowledge.	1. SG support students in recognizing BIV learning content. 2. Participants have higher learning outcomes compared to a conventional presentation when provided with a version of the SG that uses integrated debriefing

Figure 7: Overview of the Main DSR Contributions of this Dissertation's Projects

The project **“BIV Assistant”** draws awareness to inappropriately designed visual elements in management reports, which may be delusive and hence mislead decision-makers in their decision process. The project addresses a possible root cause: users’ lack of compliance with BIV guidelines due to unsatisfactory software support (Riedner & Janoschek, 2014). In **essay 1**, we introduce the key novelty of this research project, which is to employ UAS, a technology that is well known in other domains like the automotive industry (Maedche et al., 2016), to overcome the above-mentioned issue. Based on a systematic literature review, we show that no approach for implemented software that assists to reveal and amend misleading graphics based on BIV guidelines is discussed in prior scientific literature. Adding this information to the knowledge base of both research in the field UAS, as well as the field of BIV, we contribute to *exploratory research*. Moreover, we use *applied research and engineering* as our mode of inquiry in essay 1, since a first prototypical UAS called the “BIV Assistant” is introduced. Its design is deduced from the technology acceptance model and developed in a SAP UI5 environment. Referring to demonstration examples, a technical evaluation has verified that this proof-of-concept prototype can successfully detect and correct four instances of misleading visualizations. These are truncated axis, inverted timelines, filtered elements on the ordinate axis, and differently scaled axes in a combination chart.

Essay 2 reflects the second iteration of the project “BIV Assistant”. A systematic literature review revealed that design features for UAS regarding perceived ease of use, perceived usefulness, and intention to use have barely been addressed in prior literature. This is surprising since these are the main constructs of the widely employed TAM, which was developed to improve the understanding of user acceptance processes and to provide a theoretical basis for a practical user acceptance testing methodology (Davis, 1986; Venkatesh & Bala, 2008). With this finding, we contribute to *exploratory research* according to Briggs and Schwabe (2011). Building on the knowledge of the project’s first iteration, essay 2 shows a detailed design of the “BIV Assistant”. Referring to the integrated taxonomy of guidance design features proposed by Morana et al. (2017), we propose instances of design features for UAS that intend to help with complying with guidelines. This may lead to an increased perceived ease of use and perceived usefulness of our UAS and may help to increase the intention to use the “BIV Assistant”. With these design aspects, we contribute to *applied research and engineering* knowledge. To analyze the effects of perceived usefulness and perceived ease of use with regard to the intention to use UAS, essay 2 demonstrates the design and results of a within-subject experiment and hence contributes to the *experimental research* category. The experiment differentiated two measurement settings. In the first setting, participants had to identify inappropriately visualized elements being assisted by written documents of the IBCS guidelines, which are published via the website of the IBCS Association. In the second setting participants had to fulfill the same task as in the first setting, however being supported by the “BIV Assistant” to fulfill the requested task. This way, participants were able to compare our UAS with the status quo (i.e., written documents) in most companies. After the task was completed, participants were asked to answer questions on perceived usefulness, perceived ease of use, and intention to use the UAS. To assure validated items for the questionnaire, we adapted items proposed by Venkatesh and Bala (2008). In addition, open questions with regard to design features of the UAS complemented the questionnaire. The result of a multiple linear regression analysis shows that both perceived ease of use and perceived usefulness statistically significant predict the intention to use the UAS. For us, a positive result of this analysis was a necessary precondition for further research, because prior to finding ways to increase perceived usefulness and perceived ease of use, it should be shown that these factors might actually increase the intention to use UAS. To identify design aspects of UAS that are important to consider for increasing perceived usefulness and perceived ease of use, essay 2 shows the results of a summative qualitative content analysis (cf. Hsieh and Shannon (2005)) based on the answers of the open questions. With regard to perceived usefulness, the most important design features that were mentioned are the error reduction provided by the UAS, sufficient explanations as well as transparency of changes regarding the depicted charts (i.e., traceability of the actions performed by the UAS). Regarding perceived ease of use, explanations that are easy to understand (i.e., high quality explanations) and providing several languages in UAS were revealed as important design features. Even so, only a limited number of participants joined the experiment, these insights may help designers of UAS to create easy to use as well as useful systems and motivate researchers for conducting further research on design features for UAS.

The objective of **essay 3** was to investigate how UAS for BIV may affect the intention to comply with BIV guidelines in management reporting. The reason for this is, that based on a literature review, we could not identify prior research that explicitly concerns questions whether UAS may actually foster the intention to comply with guidelines. Drawing awareness to that research gap contributes to the knowledge base of UAS and may therefore be assigned to *exploratory research*. To contribute to bridging this gap, essay 3 presents hypotheses that were deduced from TAM, which we used as theoretical background. To investigate if these hypotheses hold, an evaluation design as well as results of a laboratory experiment are discussed. A laboratory experiment was chosen as the artifact already has been developed (i.e., ex-post evaluation) and due to the benefit of controlling for possibly confounding variables as well as measuring the efficacy of an artifact. We chose a within-subject design, where participants may experience report design both with and without using the "BIV Assistant". Even so within-subject experiments may be subject to possible learning effects (Charness et al., 2012), we decided to follow that design, since potential learning effects are of minor relevance when investigating the effects of UAS on intention to comply with BIV guidelines. Moreover, a within-subject experiment requires less participants compared to between-subject designs (Lazar et al., 2010). As we used a within-subject design, we conducted dependent t-tests and compared the differences between means of the variables of two measurement settings. In the first setting (T1), participants were only allowed to use written guidelines of the IBCS to identify flawed visualizations. In the second setting (T2), they could use the "BIV Assistant". The result of this analysis shows that means of all variables (i.e., perceived ease of use, perceived usefulness, report self-efficacy, and intention to comply) increased from T1 to T2. The increase in report self-efficacy was highly significant. Increases in perceived usefulness of complying with BIV guidelines as well as perceived ease of using these guidelines were marginally significant. However, although there was an increase in intention to comply with guidelines, this increase was not significant. To evaluate if the propositions from TAM hold in a non-technical environment (i.e., compliance with BIV guidelines), we conducted a multiple linear regression analysis to identify the influence of the independent variables perceived usefulness, perceived ease of use, as well as report self-efficacy on the dependent variable intention to comply. As a result, perceived ease of use significantly predicts the intention to comply with BIV guidelines and hence, we conclude that in a BIV context, perceived ease of use is especially important to foster the intention to comply with guidelines. Therefore, we claim that when designing such UAS, it is key to focus on easy to use features. With the findings of the analyzed data presented in essay 3, we contribute to *experimental research* according to Briggs and Schwabe (2011).

Although we contribute to research with our project "BIV Assistant", an important limitation is the restricted search space of our literature reviews. Rather than being exhaustive, we followed a pivotal approach since we focused on UAS as well as BIV as central aspects (Cooper, 1988). Although we focused on relevant databases and leading journals in the fields of IS, computer science, human visual perception as well as business and management, additional valuable information may be found in other sources with less scientific reputation, for instance results of workshops or working papers. Nevertheless, we suppose that our literature reviews have a satisfying degree of comprehensiveness, since researchers argue that a search can be terminated when the authors are confident of the novelty of the identified area (Boell & Cecez-Kecmanovic, 2010). Even so, the experiments of the project "BIV Assistant" were conducted with a limited number of participants and the "BIV Assistant" only offers corrections for four types of misleading visualizations, we provide first indications to what extent UAS may affect the intention to comply with BIV guidelines in management reporting. Moreover, we were able to provide specific design features that may be considered when designing UAS for BIV. In summary, we conclude that with this knowledge we contribute to gain insight to Mertens and Barbian's (2015) proposed grand challenge of developing "assistant systems to customize the parameters of Decision Support Systems", which aims at a reliable interpretation and visualization of results.

With the project **"BIV Learning Assistant"**, we address the next root cause of inadequate BIV: limited knowledge about BIV guidelines and their application due to insufficient work-integrated training possibilities (Riedner & Janoschek, 2014). Since UAS may be used to convey knowledge in a work-integrated environment (Senderek & Geisler, 2015) and since feedback is one of the most powerful influences on learning (Hattie & Timperley, 2007), it seems promising to design and evaluate a feedback-based UAS to teach knowledge about BIV guidelines and their application. The idea to use UAS for feedback-based learning, in particular for learning BIV guidelines is a novelty in the field of IS. This can be underpinned by **essay 4,** which shows that, based on a systematic literature review, such UAS could not be identified in prior literature. Although some UAS support users in learning specific tasks, none of the studies from prior research covers the aspect of a software that assists feedback-based learning of BIV guidelines in workplace learning. With identifying and communicating this research gap, we contribute to *exploratory research*. Moreover, essay 4 deduces design requirements for UAS from FIT. Based on that knowledge, essay 4 employs *applied research and engineering* as mode of inquiry and presents a first prototypical UAS that aims at feedback-based learning of BIV guidelines, an Excel Add In called "BIV Learning Assistant". With this artifact, we contribute to DSR since we present a novel proof-of-concept prototype.
Essay 5 builds on the knowledge gained in the previous design cycle of this project. With regard to *exploratory research*, the essay demonstrates that although various UAS that aim at supporting learning are discussed in prior literature, there is no common agreement on how to incorporate design elements for feedback-based learning in UAS. To overcome this issue, the next mode of inquiry employed is *applied research and engineering.* The essay describes in depth instantiated design features of the further developed artifact, its functionality, and its architecture. These aspects may be used for further research, since we were able to illustrate the usefulness of the artifact based on a laboratory experiment.

We conducted a one-way ANOVA with planned contrasts to assess the effects of feedback-based assistance on learning outcomes between three different groups. The groups were equipped with different means of assistance. Group A was treated with the BIV Learning Assistant, group B with an assistance system that automatically corrected inadequately designed visualizations, and group C was provided a printout of the IBCS guidelines. The results demonstrate that group A had higher learning outcomes than group B. This difference was statistically significant, .21 (SE=0.08), p=.014. Almost the same result can be reported for the comparison of group A with group C. Again, group A performed significantly better than the other group, .32 (SE=0.08), p<.001. For comparing the effects of knowledge increase caused by the means of assistance employed, a dependent t-test was conducted. For this, we compared participants knowledge states using a pre- and a posttest. If a participant did not identify a BIV error in the pretest, but managed to do so in the posttest, we considered this an observed increase in BIV knowledge. The results demonstrate that the BIV Learning Assistant was the only means of assistance that increased BIV knowledge highly significantly (p<0.001). Even so, the other means of assistance slightly increased BIV knowledge, this is increase was non-significant. Last, based on the results of a qualitative summative content analysis, we conclude that all instantiated design principles of the BIV Learning Assistant are either perceived as being directly supportive for learning or being motivating to learn. An important design aspect participants wished for, is to have the possibility to use the UAS and edit the business chart in parallel. Providing these findings based on analyzed data sets we contribute to *experimental research* (Briggs & Schwabe, 2011). Limitations may be the relatively small number of participants. The requirements to conduct a one-way ANOVA have however been successfully tested. Shapiro-Wilk test demonstrates that the data for all groups is normally distributed (p>.05), Levene's Test proves homogeneity of variances (p>.05).

In summary, the project "BIV Learning Assistant" introduces a software artifact with which work-integrated learning of BIV guidelines may be fostered. Moreover, we propose design features on how such UAS may be designed. Most important, we demonstrate the usefulness of this novel artifact based on a laboratory experiment. Hence, this project contributes to gain insight to what extent UAS support feedback-based learning of BIV guidelines. Providing these aspects to the knowledge base of UAS addresses a grand challenge proposed by Mertens and Barbian (2015), which is concerned with “personalization of instruction and training in business contexts, real-time instruction”, which has the objective to offer “help (in real-time) when an employee runs into difficulties during a task.”

The project **“Dashboard Tournament”** addresses the issue that companies scarcely strive for adequate BIV in their management reporting (Al-Kassab et al., 2014), because of limited knowledge about BIV guidelines and their application due to insufficient education in school or higher education (Kohlhammer et al., 2013). Since serious games already foster cognitive learning outcomes in other domains (Connolly et al., 2012; Wouters et al., 2009), they appear to be a promising approach to convey BIV knowledge. According to our literature review, we highlight in **essay 6** that SG that emphasize on BIV are not yet prominently discussed in prior literature. With this *exploratory research*, we contribute to the knowledge foundation of SG research by advancing the novel idea to use SG to convey BIV knowledge. Since the idea is only a first step to evaluate whether it is beneficial to use SG that improve players’ BIV skills, essay 6 and **essay 7** also employ *applied research and engineering* as mode of inquiry: the first SG about BIV was designed, a detailed architecture of the SG introduced, and a prototypical SG developed. With this artifact, we show how BIV guidelines may be conveyed with different minigames. With this, we contribute to research by providing a first proof-of-concept prototype, which lays the foundation for instances of generalizable solutions (Briggs & Schwabe, 2011). The next mode of inquiry leading to DSR contributions used in the project Dashboard Tournament is *experimental research*.

Contributing to this category, **essay 8** presents a first evaluation of the prototype and shows that motivational outcomes may be achieved, and that learning content is recognized by participants. For this first evaluation, we draw on the Game Experience

Questionnaire introduced by IJsselsteijn et al. (2008) to evaluate the scales competence, immersion, flow, tension/ annoyance, challenge, negative affect, and positive affect. The essence of the analysis shows that participants had a high experience of competency, were in a flow state, and had a positive attitude towards the game. In addition, the employed questionnaire indicates highly satisfying values with regard to their internal consistency (Cronbach's $\alpha > 0.7$), except "tension/annoyance". As a result, adapting the latter, the questionnaire may be used for ongoing research. Further, the results of our qualitative content analysis show that BIV guidelines can be identified while playing the game. **Essay 9** is the final essay of the project "Dashboard Tournament". This essay's contributions are twofold. First, we employed *applied research and engineering* as mode of inquiry. The essay presents the final version of our SG. Compared to previous versions, where a single player mode was available only, we now present a multiplayer version, where participants can compete against each other. Hence, we contribute a novel artifact to the domains of BIV and SG. The results of our experiment substantiate our SG's usefulness and constitute the second mode of inquiry: *experimental research*, which leads to hypotheses, experimental designs, and analyzed data sets (Briggs & Schwabe, 2011). We referred to self-determination theory (Deci & Ryan, 1985) to deduce the essay's hypotheses. To measure if these hypotheses hold, we adjusted the intrinsic motivation inventory (Ryan, 1982) and combined it with items from the game experience questionnaire (de Kort et al., 2007). With this novel complementary questionnaire, we were able to demonstrate that one of the most important dependent variables, namely intrinsic motivation, significantly differed between the groups with integrated debriefing and the widely used post-hoc debriefing. The group with integrated debriefing reported significantly higher intrinsic motivation. Surprising, however, is that compared to a more conventional instructional approach (i.e., a presentation), there were no significant differences in motivation. Although being not more motivated, the results indicate that participants have higher learning outcomes than a conventional presentation when provided with a version of the SG that employs integrated debriefing.

Summing up the contributions of the project “Dashboard Tournament”, we conclude that our developed questionnaire can serve as a measurement instrument for future research. In addition, with our analyzed data sets, we were able to show that SG with integrated debriefing may be beneficial in terms of learning outcomes and motivation compared to SG with post-hoc debriefing. This is especially of interest, since post-hoc debriefing is widely employed in SG. Of course, we also have to consider the project’s limitations. In its current version only four minigames were developed, which might limit our findings to relatively small game experiences. However, since we argue that the differences in learning outcomes are based on the difficulty to remember what happened during the game experience, we expect that this effect even increases when participants are involved in longer lasting game experiences. Therefore, with our finding we add an important design principle to the knowledge base of SG design, which we suggest to be employed by SG developers.

Summarizing the outlined, we conclude that the essays described in this dissertation constitute novel contributions with regard to how compliance with BIV guidelines and learning such guidelines can be supported with UAS and SG. With the conducted literature reviews, we were able to report challenges in the user environments of UAS and SG. Findings comprise that UAS for BIV are not yet discussed prominently in prior scientific literature. Therefore, we provide a novel prototypical UAS for BIV that aims at assisting to comply with BIV guidelines. Since research on design features that increase the constructs of the TAM (i.e., perceived usefulness, perceived ease of use, and intention to use UAS) are scarcely addressed in the field of UAS for BIV, we used the “BIV Assistant” to identify such design features. Based on laboratory experiments, we additionally provide insights that UAS may increase perceived ease of use, perceived usefulness, and intention to comply with BIV guidelines.

Although UAS are a promising approach to convey knowledge, we showed that UAS that assist in learning BIV guidelines are barely discussed. To overcome this issue, we provide a second artifact called the “BIV Learning Assistant” to investigate whether the use of UAS is beneficial in a work-integrated learning environment. In particular, we compare the BIV Learning Assistant to UAS that automatically correct inadequately visualized elements as well as written documents, which we refer to as conventional work-integrated learning assistance. The efficacy of our artifact was evaluated in between-subject laboratory experiment. A one-way ANOVA with planned contrasts demonstrated the effects of feedback-based assistance on learning outcomes. The results show that participants, who used the BIV Learning Assistant as means of assistance had significantly higher learning outcomes than the group that applied a UAS that automatically corrected inadequately visualized elements and the group that used a printout of BIV guidelines as means of assistance. Based on the results of a dependent t-test, we were able to show that only the BIV Learning Assistant increases BIV knowledge highly significantly. A summative qualitative content analysis demonstrated that all instantiated design principles of the BIV Learning Assistant are perceived either as being directly supportive for learning or being motivating to learn. An important design aspect that we missed to implement was the possibility to use the UAS while editing the business chart.

Next, we were able to identify that SG are scarcely used to transfer BIV knowledge, although they are already used to foster cognitive learning outcomes in other domains. To shed light on whether SG are superior compared to more conventional instructional methods (i.e., presentations), we introduced our third artifact, a SG called “Dashboard Tournament”. The results of our evaluations indicate that integrating debriefing into SG may be beneficial in terms of learning outcomes and motivation compared to SG with post-hoc debriefing.

To address the limitations of this dissertation, we have to mention that there might be research outlets that may bear relevant information, which we did not consider in our systematic literature reviews. However, since we address the multidisciplinary of the field of BIV by considering literature from leading journals and conferences in IS, computer science, human visual perception, as well as business and management, we believe that our literature reviews have a satisfying degree of comprehensiveness. Another limitation might be that we employed artifacts that only address a limited number of BIV guidelines and use laboratory experiments for our evaluations. We argue however, when employing DSR, a logical first step to gain insight in scarcely investigated research fields, is to start with prototypes and chose experimental designs with which possible confounding effects can be controlled. This is why we chose to conduct laboratory experiments with artifacts that have a satisfying degree of maturity for evaluating our assumed effects. Future research may focus on field studies while using more elaborated artifacts. Nevertheless, it can be claimed that this dissertation provides fundamental contributions for various aspects in both, the domain of UAS as well as SG. It introduces three novel artifacts that each allowed contributing to bridge key problems of non-compliance with BIV guidelines as well as conveying BIV knowledge. Future research may use and further develop these artifacts to conduct not only laboratory experiments, but field studies in order to substantiate further research. Second, to assure appropriately designed artifacts we provide specific design features that help to design useful and ease to use UAS. In particular, with regard to perceived usefulness these design features are error reduction provided by the UAS, sufficient explanations, and transparency of changes. For perceived ease of use, designers may account for easy to understand explanations and multilingualism. Referring to the aspect of compliance with BIV guidelines, this dissertation provides insight that perceived ease of use is key to foster compliance with such guidelines. Although, the domain of UAS for BIV is subject of this dissertation's research, the findings may be generalized for the field of UAS, in particular for UAS that aim at supporting compliance. In the context of learning, it is indicated that UAS help to achieve superior learning outcomes in workplace learning compared to more conventional assistance for learning. Moreover, this dissertation illustrates that UAS that display a clear goal and provide functionalities such as hinting at errors, providing corrective feedback and support in achieving a goal (e.g., by providing video instructions) are a superior learning aid compared to UAS that automatically correct errors. Last, this dissertation provides an important design aspect in the field of SG. Participants have higher learning outcomes compared to conventional presentations when being provided with SG that use integrated debriefing instead of post-hoc debriefing.

Hence, we conclude that our results are relevant to both, researchers as well as practitioners and indicate novel and useful first findings in the fields of UAS and SG for BIV. With this dissertation, we therefore help to lay the foundation to comply with BIV guidelines and thus ultimately support managers and executives to make better decisions based on appropriately visualized business reports.

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