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The Effect of Various of Example-Based Learning on Learning Achievement and Satisfaction in Educational Statistics Courses

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Abstract: Example-based learning has been studied from different perspectives. Cognitive research has mainly focused on worked examples, which typically provide students with a written worked-out didactical solution to a problem to study. Social-cognitive research has mostly focused on modeling examples, which provide students the opportunity to observe an adult or a peer model performing the task. The present study aims to compare university students' performance and satisfaction in various example-based learning. It involves paper-based examples (PBE), video-based examples (VBE) and mixed-based examples (MBE). An experimental study was administered with the participation of 36 undergraduate students who are enrolled in their third-year studies at a private university in Banten, Indonesia. The study findings reveal that MBE is superior in promoting students' performance and satisfaction in example-based learning. It can be concluded that MBE stimulates higher learning performance and satisfaction. These findings complement previous studies with additional insight into learning satisfaction. Due to the focus of this study and the tendency of previous studies which were mainly experimental, it is recommended for conducting narrative studies in the future to disclose detailed performance and satisfaction per individual case.

Keywords: educational statistic, example based learning, satisfaction, learning performance.

▪ INTRODUCTION

Example-based learning has been recognised as an effective educational approach to facilitate knowledge acquisition and skills mastery of novice learners in complex courses. This approach utilises various examples to guide or demonstrate problem-solving tasks so that is possible to imitate procedures for different problems (Renkl, 2014). The provided examples could be text-based which is the so-called worked examples (Atkinson et al., 2000; Ward & Sweller, 1990) or video-based which is the so-called modelling examples (Bjerrum et al., 2013; Hoogerheide et al., 2016). Decreasing the cognitive load of students is one main instructional benefit of learning through examples. Complex tasks may be solved easily even by beginners should appropriate worked or modelling examples are served.

Research on example-based learning which considers learners' performance and satisfaction simultaneously are by far sparse. Available studies tend to focus on motivational and cognitive learning outcomes while less so on experiences (Hoogerheide et al., 2014a; X. Huang, 2017; Kaiser & Mayer, 2019; Van Harsel et al., 2022; Wittwer & Renkl, 2010). Hoogerheide et al. (2014a) compared the effects of worked examples and modelling examples on learning outcomes, cognitive load and self-efficacy to perform mathematical problem-solving tasks. The experimental study was participated by 78 secondary school students in the Netherlands and involved text-based examples and video-based examples with and without a visible model in mathematics learning within a topic of probability. Results from immediate and delayed post-tests concluded

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that all three types of example-based instruction were equally promising to increase performance and decrease mental effort for solving problems. Unexpectedly, there was also no significant difference in their contribution to students' problem-solving confidence.

A similar study was conducted by Huang (2017) who compared the effectiveness of four different forms of example-based learning, namely standard worked examples, erroneous worked examples, expert modelling examples and peer modelling examples, to enhance performance, manage cognitive load, and learning confidence in a statistics course. It was participated by 116 undergraduate students across different disciplines and grade levels at a private university in the United States. The findings indicated that the most effective examples to foster knowledge acquisition and near as well as far transfer of knowledge are expert modelling examples. Further, peer modelling examples were more effective than the other examples in increasing self-efficacy. The erroneous worked examples were unexpectedly least effective in terms of performance and self-efficacy although previous studies recommended their benefits for learning. Standard worked examples have no surprising or significant effects on the study.

A comparison among worked examples, modelling examples, and practice problems was conducted by Van Harsel et al. (2022) on how students regulate their statistics learning with the topic of the trapezoidal rule. Besides implementing different examples, the study which involved 147 university students in the Netherlands, divided the learning path into three different levels of task complexities. It was found that students started their learning with video examples from the lowest complexity level. They increased task complexity gradually while decreasing example selection. Throughout the whole learning process, video examples and the lowest level of tasks are by far the most popular examples and tasks.

Video-based examples appear as a prevalent form of modelling examples and a more popular way than text-based or worked examples in the current practices of example-based learning. Kaiser & Mayer (2019) investigated the long-term benefits of video modelling examples for guided inquiry in junior high schools. It was revealed that video modelling examples play a crucial prerequisite for long-term guided inquiry as they facilitate stable problem-solving schemes, but the long-term retention of structured inquiry did not depend on video modelling examples. Results from the study by Kant et al. (2017) suggested providing sequential videos to support scientific reasoning. In a broader context, video has been implemented to effectively facilitate learning in a variety of educational modes (Giannakos et al., 2014; Othman et al., 2022; Standl et al., 2021).

Other studies connect text-based or worked examples with self-explanation for more powerful science learning. This combination appears as an appropriate strategy for better stimulating self-regulated learning and enhancing learning performances. Through a quasi-experiment study participated by 66 secondary school students, Crippen & Earl (2007) found that worked examples supported with self-explanation prompts are effective in improving performance, problem-solving skills, and self-efficacy. The study of Hiller et al. (2020) compared closed-book and open-book self-explanation prompts in worked examples. Involved 96 secondary school students, the study found that the open-book ones promote more active engagement and higher outcomes.

Existing studies also consider novice and proficient learners in example-based learning. An experimental study by Huang (2015) which was participated by 93 university students across disciplines found that example-based learning contributes significantly to learners who have low prior knowledge. The study concludes that the level of learners' prior knowledge determines the effectiveness of certain instructional procedures in example-based learning. Dyer et al. (2015) invited 91 novice learners from a public university in Canada to a study comparing the effects of self-explaining, completing a concept map and studying a concept map on conceptual knowledge and problem-solving skills in example-based learning. This study found that self-explanation after completing worked examples produces better performance in novice learners.

Too much attention has been paid to the effect of example-based learning on certain outcomes such as engagement, performance, self-efficacy and self-regulated learning. It is crucial to study example-based learning exposures for practical reflection and improvement of practices. Investigations on this issue could reveal how example-based learning appeals to students. Several studies have suggested comparing the effectiveness of various example-based learning forms. Each typical format, such as worked or modelling examples, has different instructional benefits (Van Gog & Rummel, 2010). They feature some commonalities but also differences in terms of advantages for learning so comparing both approaches is worth studying. Example-based learning is an emerging field that starts from simple ideas such as text-based worked examples (Ward & Sweller, 1990) to more sophisticated like eye-movement modelling examples (Wright et al., 2022). Evidence from recent studies recommends further examining performance, motivation, and experience in various example-based learning. This endeavour continues the long tradition of investigation in learning through a set of examples.

The present study compares university students' performance and satisfaction in various example-based learning. The comparison involves paper-based examples (PBE), video-based examples (VBE) and mixed-based examples (MBE). Twofold questions were posed in this study:

- How was university students' performance in example-based learning facilitated by PBE, VBE and MBE?
- How was university students' satisfaction with PBE, VBE and MBE in example-based learning?

Literature Review

Example-based learning refers to an instructional approach that relies on the use of examples to acquire either new knowledge or skills. Provided with a set of examples, students observe and analyse them to understand underlying patterns, principles, or concepts (Renkl, 2014). This learning approach is often employed in problem-solving tasks or domains where there are clear examples of desired outcomes and behaviours. The approach has multiple benefits for learning as it provides concrete and contextualised experiences (Stark, 2004), promotes active engagement and critical thinking (Hefter & Berthold, 2022), enhances problem-solving abilities and enables students to apply their knowledge in real-world contexts (Hoogerheide & Roelle, 2020).

Learning through examples typically involves iterative four steps, namely observation, abstraction, generalisation, and evaluation (Van Gog & Rummel, 2010). It is started with closely observing provided examples to find relevant features, relationships, or patterns. In the abstraction phase, students extract general principles or rules from the observed examples by identifying commonalities and key features that are essential to understanding the concept or behaviour being learned. Generalisation means that students apply the extracted principles or rules to new situations or problems. Finally, they have to reflect on the effectiveness of their generalisations by receiving feedback from peers, instructors or experts.

There so far two main forms of learning supported by examples: worked examples and modelling examples. Worked examples as a specific type of example-based learning provides students with step-by-step demonstrations or solutions to problems (Van Gog et al., 2004). The purpose of using worked examples is to enhance learning by providing a clear and structured demonstration of how to solve a problem or complete a task (Sweller & Cooper, 1985). It contains explicit and detailed guidance that breaks down complex tasks into manageable steps, helps to reduce cognitive load by presenting the problem-solving steps in a clear and organised manner, and facilitates the transfer of learning to new and unfamiliar problems.

Modelling examples refer to examples that are specifically designed to demonstrate a particular concept, skill, or behaviour. These examples serve as models for students that provide a clear representation of the desired outcome or performance (Van Gog et al., 2014). This type of example-based learning enables students to see the correct or effective way of performing a task, engage in observational learning, and mentally simulate actions or outcomes without physically performing the tasks (Hoogerheide et al., 2014b). Modelling examples are promising to reduce learning uncertainty as learners could imagine the expected outcomes and understand the correct procedures from the demonstrations.

The present study has taken these characteristics into account. It works with paper-based examples (PBE) as worked examples, video-based examples (VBE) as modelling examples, and mixed-based examples (MBE) as a combination of worked and modelling examples. The comparison between worked examples and modeling examples is analogous with the comparison dynamic presentations and static presentation. According to Betrancourt etc (2000), a dynamic presentation is any type of representation that involves a sequence of frames, where each frame modifies the previous one and illustrates a temporal progression. Thus, the term video-based examples encompasses a rapid sequence of images, such as those captured by a camera. Incorporating videos in educational contexts offers several advantages over static images (Höffler & Leutner, 2007; Park & Hopkins, 1993). First, videos employ analogical information (i.e., using iconic and visual depictions rather than symbolic descriptions), facilitating the creation of internal representations for viewers (Schnotz & Rasch, 2005) and meaningful learning (Ausubel, 1962, 1963). This advantage is particularly apparent in learning scenarios involving content with substantial visual-spatial elements, such as the configuration of three-dimensional physical systems (Mayer et al., 2005) or the spatial layout of elements, like atmospheric systems on a map (Lowe, 1999).

Second, videos inherently involve a rapid sequence of images that depict movement, emergence, and disappearance of graphical elements, making them well-suited for illustrating dynamic information that evolves over time due to their temporal coherence (Tversky et al., 2002). Third, as videos provide a continuous stream of information, they offer more detail than a series of static images. This continuous format effectively demonstrates the micro-steps between each significant change, making video-based examples ideal for presenting continuous phenomena. Learners do not need to infer how one state transitions to the next (Bétrancourt & Tversky, 2000). Fourth, recent studies indicate that video are particularly beneficial for teaching certain human-motor skills, such as knot-tying or paper-folding, where videos outperform static images (Ayres et al., 2009; Van Der Meij et al., 2014; Wong et al., 2009). However, despite their advantages, video have not consistently shown effectiveness in educational settings (Bétrancourt & Tversky, 2000). One possible explanation for the limited effectiveness of animations is their transient nature. Since animations present information dynamically and at a fixed pace, learners may struggle to fully process content that briefly appears and then disappears (Ainsworth & VanLabeke, 2004; Ayres & Paas, 2007b). Maintaining critical information in working memory while constructing a coherent internal representation can increase cognitive load (Sweller, 1988; Sweller & Chandler, 1994). In such cases, learners cannot control the timing of the disappearing content.

In contrast, paper-based examples allow learners to navigate content at their own pace-skimming some sections quickly, lingering over others, and re-reading when necessary (Arguel & Jamet, 2009). With video-based presentations, missing crucial information results in permanent loss, necessitating that learners hold important details in working memory until they can be integrated with subsequent information. This makes retaining and integrating information particularly demanding on working memory resources (R. C. Atkinson & Shiffrin, 1968; R. K. Atkinson, 2002).

There are two strategies to address the challenges associated with video transient nature. First, some information loss can be mitigated by displaying key static images from the video, reducing transience (Schnotz & Bannert, 2003). This allows learners to revisit earlier content as needed. However, in most cases, the dense content of animations makes this solution impractical due to potential perceptual overload, leading to unclear visuals. Second, providing learners with control over the pace of the content—through a “slider bar” or “stop” and “play” buttons—can enhance instructional video effectiveness (Brunyé et al., 2006; Hasler et al., 2007). Allowing learners to control the content’s pace prevents information loss and enables slowing down when material becomes challenging. Moreover, this control can facilitate learning about cause-and-effect systems by segmenting content into manageable chunks (Sweller & Chandler, 1994).

Nonetheless, controlling the pace of learning material has its challenges. Using an interface to regulate pace adds another layer of cognitive demand, which may distract learners from the primary task (Hegarty et al., 2003a). Additionally, proficiency with the interface is required, which can be particularly problematic for individuals less familiar with digital tools. Moreover, controlling pace requires learners to actively decide which information is most relevant—a task that can increase cognitive load if appropriate strategies are lacking (Lowe, 1999; Schwan & Riempp, 2004). This added demand sometimes leads learners to avoid interactive controls altogether. For instance, Hasler et al. (Brunyé et al., 2006; Hasler et al., 2007) (2007) observed that learners given control over video performed better than those without control, despite rarely using the interactive feature. This discrepancy might be attributed to the instructions given before the learning phase. Research by Hegarty et al. has demonstrated that learners benefit from explicit instructions to actively engage with material—such as mentally animating systems—resulting in better outcomes compared to those without such guidance (Hegarty et al., 2003b). In Hasler et al.'s study, participants who were encouraged to use interface controls likely engaged more actively with the content, even if they did not manipulate the controls frequently.

Documents describing procedural content involve the evolution of phenomena or a sequence of actions over time, characterized by a defined beginning and end, with a series of steps in between. The correct order of these steps is crucial; reversing them can disrupt the process or obscure its meaning. Therefore, multimedia presentations may serve as a useful alternative to traditional paper-based documents for learning procedural content (Brunyé et al., 2006).

To maximize the benefits of video-based example for conveying temporal information while mitigating their limitations, an alternative format has been proposed. This format combines video and reprsentasion images, maintaining the depiction of procedural micro-steps while reducing the impact of video transient nature. Using static frames from the video can minimize the split attention effect (Ayres, 2006; Ayres & Paas, 2007b, 2007a). Spoken narration enhances this approach by adding verbal information to the visual domain, allowing learners to focus on visual details without dividing their attention between text and images. This approach aligns with the modality principle, which emphasizes the benefit of distributing information across visual and auditory channels (Moreno & Mayer, 2007).

In mixed-based example, a flowchart of the statistical testing procedure is presented in the video, reducing cognitive load by allowing learners to revisit content at any time. These images can replace the need for pace control, providing stable reference points without requiring learners to interact directly with the content. According to meaningful learning, learners construct internal representations in discrete steps, not continuous flows (Zacks & Tversky, 2003). Supplementing videos with static images might create external representations closer to learners' mental models than videos alone, reducing the gap between external and internal depictions. Consistent with the congruence principle from multimedia learing theory (Mayer, 2021), such combined material should enhance learning effectiveness compared to video-only visualizations (Tversky et al., 2002).

▪ METHOD

This section describes the implemented research design, population, instrument, validity and reliability tests. These aspects were elaborated and justified in the next passages.

Research Design and Procedures

Experimental study was administered to achieve the main research objective: comparing performance and satisfaction in example-based learning. The study examined these matters within three different types of example-based learning: paper-based example (PBE), video-based example (VBE) and mixed-based example (MBE) that combines paper-and video-based examples. In the PBE, a research case and statistical data to be tested are presented, followed by statistical testing steps and interpretation of the results. In the VBE, it is the same as the paper-based example, the difference is that participants can get an explanation of the research case, data to be tested, and statistical testing steps and interpretation of the results using video. In the MBE, just like the video-based example, it is added with a statistical testing procedure chart throughout.

Procedure of this experiment was divided into four phases. Firstly, selected students received an orientation regarding this study. This step introduces the main aims and planned research activities. Secondly, students participated in a learning session facilitated either by paper-, video- or mixed-based examples. Thirdly, once the session was over, students played the quiz. Fourthly, students are asked to work on a performance test to measure their ability to perform statistical tests and interpret the results. Finally, students are asked to answer a satisfaction questionnaire.

Participants

This experiment was conducted in a statistics course on the topic of Paired Sample T-Test. Randomly selected from 180 candidate participants, the study involved 36 undergraduate students who are enrolled in their third-year studies at a private university. Regarding gender, there are 19 (52.78%) male and 17 (47.22%) female students. Participating students have shared prior knowledge and no have experience in performing the t-test. of the 36, they are divided into three groups. Each group learns with a sequence of four stages as previously explained. The difference is, each group learns with different media.

Instruments

To measure performance, a variety of assessments were managed by a quiz and test. The quiz has eight multiple-choice questions to evaluate students' understanding of rule in perform t-test, that is concept of paired sample t-test or wilcoxon signed-rank test, formulation of hypotheses, interpreting of normality test, cheking of data outliers, interpreting for data outliers, selection of hypothesis test based on result of normality test, concept of hypothesis testing, and interpretation result of t-test. Example questions: paired sample t-test or Wilcoxon signed test is a statistical test used in research ... a. correlational, b. experimental, c. quantitative, and d. qualitative. Before used, validity and reliability tests were conducted. From the test results, it is known that the eight questions are valid. From the reliability test, it is known that the questions are reliable with a Cronbach alpha value of 0.914.

Tests were designed to examine their ability to perform and interpret t-test outputs. We asked participants to perform statistical tests based on the data provided and asked for answers to the following questions: Based on the test results on the data provided, explain: 1. Is the data normally distributed; 2. Are there any outliers?; 3. Is the data homogeneous?; 4) Does the data meet the requirements for the paired sample t-test?; 5) Is the difference in learning outcomes between the two groups significant?. Each correct answer is given 1 point. To assess the answers, an assessment rubric is used. Before being used, we invited 11 material experts (lecturers in charge of the Educational Statistics course) from the Program Studi S1 matematics FMIPA Universitas Pamulang to assess the rubric indicators.

The data were entered in SPSS and we used the intraclass correlation coefficient (ICC), as the method to compute the interrater reliability of the rubric. The ICC is calculated by dividing the random effect variance, by the total variance, i.e., the sum of the random effect variance and the residual variance. The reported ICC is the variance for each (random effect) group compared to the total variance of the model. The ICC, thus, assesses the reliability of ratings by comparing the variability of different ratings of the same subject to the total variation across all ratings and all subjects. For the inter-rater reliability, the oneway Intraclass Coefficient of .753 (p< .001) showed a good level of agreement among raters. We calculated internal consistency reliability using Cronbach's alpha. Our analysis showed that Cronbach's alpha was .897 (p < .001), indicating high congruence with the group mean scores. Cronbach's alpha for standardized items was .904, suggesting an exceptional level of consistency among the five rubric items, signifying that these items collectively assessed a shared construct related to the performance rubric of the paired t-test or Wilcoxon signed-rank test.

To measure satisfaction, a learning satisfaction questionnaire was adopted from Alexander (2013) consisting of eight of items. It consists of three variables: level of comfort (for example: "I felt comfortable using the print instructions to perform the tasks"), ease of use (for example: "The print instructions were easy to use as a reference as I was performing the tasks"), and ease of remembering (for example: "I could easily remember information from the print instructions as I completed the tasks"), which is complemented by another one called overall usability. Our analysis showed that Cronbach's alpha for standardized items was 0.860, suggesting an exceptional level of consistency among the items.

Data Analysis

The generated data from the quiz, tests, and questionnaire are quantitative in nature. The two-way multivariate analysis of variance (two-way MANOVA) is used to determine whether there are any differences between independent groups on quiz, test, and satisfaction score. When we choose to analyse data using a two-way MANOVA, we checking to make sure that the data has want to analyse can actually be analysed using a two-way MANOVA (Hair et al., 2019). First, there can be no univariate outliers in each group (PBE, VBE, and MBE) for any of the dependent variables (quiz, test, and satisfaction). Check for multivariate outliers using a measure called Mahalanobis distance, shows no symptoms outliers. Using the Shapiro-Wilk test of normality, it is known that the data for each group is normally distributed (SW=0.909, p=0.560, sig.=0.05). Using Box's M test of equality of covariance, it is known that the data is homogeneous (X2=38.413, p=0.087, sig.=0.05). From checking the analysis requirements, it is known that the data meets the requirements for further testing. Hypothesis testing is carried out to determine the significance of the differences between the three groups. From the Hotteling-Lawley Test as shown in Table 1, it is known that there are significant differences between the groups. (df=1;33, p=0.001, sig,=0.05). Two-way manova is post-hoc (Hair et al., 2019), to determine the differences in quiz scores, tests, and satisfaction between the three groups, an ANOVA test is carried out.

Table 1. Manova: Hotteling-lawley test

MANOVA: Hotelling-Lawley Test ▼

Cases	df	Approx. F	$Trace_{H-L}$	Num df	Den df	p
(Intercept)	1	4964.548	480.440	3	31.000	< .001
Group	2	31.058	6.212	6	60.000	< .001
Residuals	33					

▪ RESULT AND DISSCUSSION

This section presents the gathered data from the study. Concerning the research aims, it provides a comparison of university students' performance and satisfaction in various example-based learning. Data regarding these concerns were carefully visualised and described in the following subsections.

Performance

University students' learning performance was measured by quizzes and tests. Figure 1 below visualises the average students' performance from paper-, video- and mixed-based examples. Corresponding example-based learning can be seen from different bar chart colours.

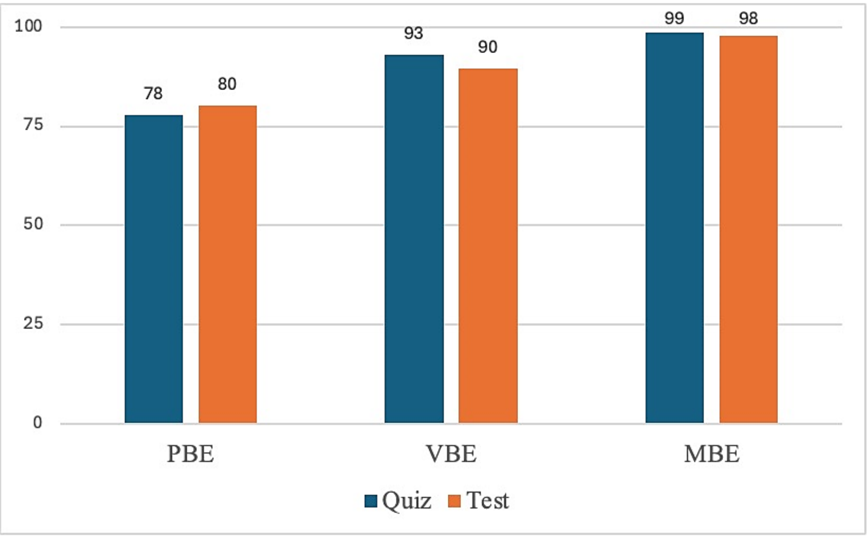

Figure 1. Performance comparison

Figure 1 compares the average university students' learning performance from paper-, video- and mixed-based examples. It is clear that performance on the MBE is constantly higher at all measurements. For PBE, performance slightly improves from quiz to test, while for VBE and MBE, performance remains relatively stable or drops slightly. MBE has the highest overall performance, followed by VBE and PBE. Either from quizzes or tests, the scores from MBE overshot that of other example-based learning reaching over 95. The maximum score that students can reach in PBE is around 80 while in VBE is around 90 at all evaluations.

Table 2. Manova test

Cases	df	Approx. F	TracePillai	Num df	Den df	P
(Intercept)	1	4964.548	0.998	3	31.000	< .001
Group	2	9.737	0.954	6	64.000	< .001
Residuals	33					

Table 2 shows the results of the MANOVA test to compare the average test scores from paper-based, video-based, and mixed learning examples, indicate that there are statistically significant differences between the groups, with a very large effect size.

Table 3. Anova: Quizz

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	289802.778	1	289802.778	3283.602	< .001
Group	2808.722	2	1404.361	15.912	< .001
Residuals	2912.500	33	88.258		

Table 3 shows the results of the ANOVA test to compare the quiz scores from paper-based, video-based, and mixed learning examples, indicate there are a highly significant difference between the groups (F=15.912, p<.001). This suggests that the various example based learning have a strong and statistically significant influence on quiz score. Figure 1 indicate that MBE has the highest quiz score, followed by VBE and PBE.

Table 4. Anova: Test

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	288369.000	1	288369.000	5075.294	< .001
Group	1842.000	2	921.000	16.210	< .001
Residuals	1875.000	33	56.818		

Table 4 shows the results of the ANOVA test to compare the test scores from paper-based, video-based, and mixed learning examples, indicate there are a highly significant difference between the groups (F=16.210, p<.001). This suggests that the various example based learning have a strong and statistically significant influence on test score. Figure 1 indicate that MBE has the highest quiz score, followed by VBE and PBE.

Regarding performance, it is noticeable that VBE and MBE invariably promote higher learning outcomes. This finding is in line with Huang (2017) who found that expert and peer modelling examples are more effective to increase performance, decrease cognitive encumbrance and nourish self-efficacy than those of standard and erroneous worked examples. Learning through live demonstration video examples exhibits an understandable representation of the desired objectives (Van Gog et al., 2014). It empowers students to imitate the demonstrated procedures by observing and mentally stimulating the steps (Hoogerheide et al., 2014b). The current evidence refutes Hoogerheide et al. (2014a) as they found that all types of example-based learning share equal contributions to performance, mental effort and self-efficacy. One explanation might be due to the characteristics of participants who are proficient learners. Mixing both paper- and video-based examples strengthen example-based learning as worked examples present step-by-step written and demonstrations structured (Sweller & Cooper, 1985; Van Gog et al., 2004). This combination accommodates multiple modalities from visual to auditory and kinesthetic as well as diverse learning styles. It is suggested to consider not only worked examples but also modelling examples in example-based instruction.

The MBE's superiority is not surprising. MBE can maintaining the depiction of procedural micro-steps while reducing the impact of video transient nature. Using static frames from the video can minimize the split attention effect (Ayres, 2006; Ayres & Paas, 2007b, 2007a). Spoken narration enhances this approach by adding verbal information to the visual domain, allowing learners to focus on visual details without dividing their attention between text and images. This approach aligns with the modality principle, which emphasizes the benefit of distributing information across visual and auditory channels (Moreno & Mayer, 2007). Selain itu, MBE can facilitating the creation of internal representations for viewers (Schnotz & Rasch, 2005) and meaningful learning (Ausubel, 1962, 1963). This advantage is particularly apparent in learning scenarios involving content with substantial visual-spatial elements, such as the configuration of three-dimensional physical systems (Mayer et al., 2005) or the spatial layout of elements, like atmospheric systems on a map (Lowe, 1999).

Students performed lower in tests of PBE and VBE. This was surprising evidence since there was only a slight difference in long-term retention among the provided example-based learning. Test practices reinforce memory retrieval and strengthen memory traces associated with the learned information. It is relatively challenging to remember technical procedures after some periods compared to that of abstract knowledge. Meanwhile, the least decrement happened on MBE. Integration of worked and modelling examples seems to be better in maintaining longer retention. Combining two sets of examples, or even more types of examples as shown in the studies of Crippen & Earl (2007), Hiller et al. (2020), Huang et al. (2015), and Dyer et al. (2015) facilitates students to engage with problem-solving tasks through different senses, allowing them to recall and retain information over time. It can be said that the more senses are involved in learning, the longer memory is recorded. Therefore, regardless of which examples are used, the example-based learning design should also have to pay adequate attention to short-term and long-term memories.

Satisfaction

University students' learning satisfaction was measured by several variables, namely level of comfort, ease of use and ease of remembering. Figure 2 below, which also reports the overall usability, describes the mean and standard deviation scores of students' satisfaction from paper-, video- and mixed-based examples.

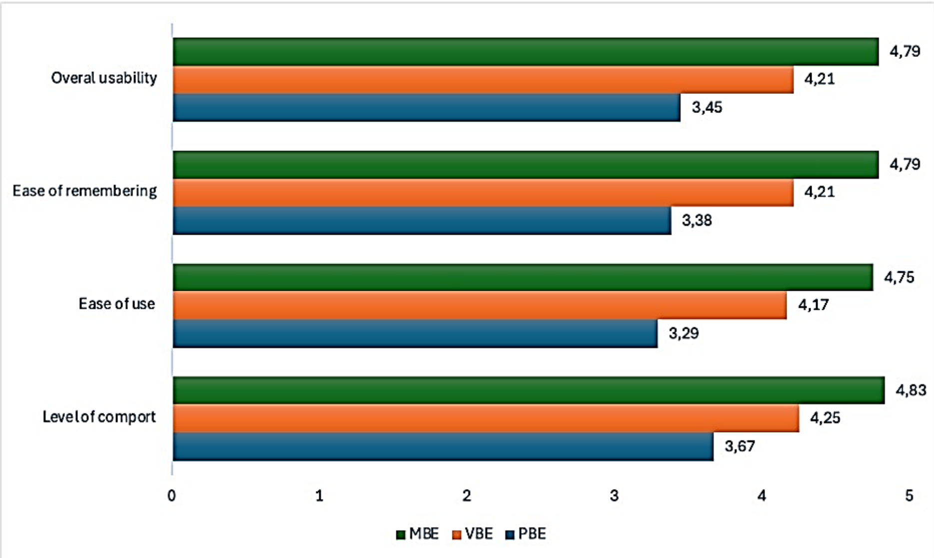

Figure 2. Satisfaction comparison

Figure 2 compares the mean and standard deviation values of university students' learning satisfaction from paper-, video- and mixed-based examples. Overall, the students are more satisfied with MBE in all satisfaction variables. The average satisfaction score of MBE reaches over 4.75 whilst that of PBE and VBE are significantly lower at 3.45 and 4.21 respectively. Further, it is interesting to underline that comfortability appears as the most influential factor determining satisfaction as this variable receives the highest rate from all groups. Regarding the data deviation, they are relatively high with scores over 0.5 in all variables and groups.

Table 6. Anova: Satisfaction

Cases	Sum of Squares	df	Mean Square	F	p
(Intercept)	38940.444	1	38940.444	7973.328	< .001
Group	672.389	2	336.194	68.838	< .001
Residuals	161167	33	4.884		

Table 6 shows the results of the ANOVA test to compare the satisfaction scores from paper-based, video-based, and mixed learning examples, indicate there are a highly significant difference between the groups (F=63.838, p<.001). This suggests that the various example based learning have a strong and statistically significant influence on satisfaction. Figure 2 indicate that MBE has the highest satisfaction, followed by VBE and PBE.

Regarding satisfaction, it was not surprising that students are more satisfied with example-based learning delivered by combining paper-based and video-based examples. This combination brings the advantages of both examples into one package, resulting in more comfortable, straightforward and understandable learning. Paper-based examples facilitate students to easily learn the steps with minimum technology in hand (Sweller & Cooper, 1985). Video-based examples promote more details step-by-step explanations (Van Gog et al., 2014). Although previous studies from Van Harsel et al. (2022), Kaiser & Mayer (2019), and Kant et al. (2017) found that students are in favour of modelling examples, it seems that paper-based examples are a great point to start. When the procedures are becoming more complicated, providing detailed explanations through videos is fruitful to them. Which examples should be provided depends on the task's complexity.

MBEs tend to be more satisfying than PBEs and VBEs for the following reasons. First, visualization facilitates comprehension. Graphs provide a visual representation that facilitates comprehension of often abstract or complex statistical concepts and procedure (Mayer & Moreno, 2003). Seeing the steps visually helps learners understand the flow of statistical logic more clearly, compared to hearing only verbal explanations that may be difficult to follow. This is in line with multimedia theory, that learning is better not just from words, but from words and pictures (Zhang et al., 2006).

Second, it enhances information retention. Research shows that information presented visually tends to be more memorable (Mayer, 1997). Graphics help simplify complex sequences of steps, resulting in better understanding and retention of knowledge (Mayer et al., 1996). Third, it captures attention. Graphics and visuals can increase viewer interest and engagement (Young et al., 2024). Videos that only present verbal information can feel monotonous, while graphics add variety and dynamics that make videos more interesting to follow. Thus, videos that utilize procedure graphs provide a richer, more effective, and more efficient learning experience in understanding complex material such as statistical tests.

▪ CONCLUSION

The present study has compared university students' performance and satisfaction in learning through paper-, video- and mixed-based examples. From the research results it can be concluded that mixed-based examples (MBE) are superior in bolstering performance and satisfaction. This evidence suggests a combination of various examples to facilitate novice learners in complex problem-solving tasks. The tasks' complexity determine which examples should be provided by also considering short-term and long-term memories.

The results of this study have implications for the selection of learning media. The results show that the combination of visual graphics and videos is an option that can improve learning outcomes and learning satisfaction. The use of videos equipped with procedural graphics, especially for complex materials such as statistics, has important implications for teaching strategies and the selection of learning media. The use of graphics in videos helps break down difficult-to-understand concepts into simpler and more structured parts. This makes the material more accessible to various types of learners, both those who learn visually, auditorily, and kinesthetically. The addition of graphics allows learners to see the relationship between the concepts being taught, which supports analytical and synthetic thinking processes. As a result, meaningful learning occurs. In addition, graphics help reduce cognitive load by presenting information more clearly and structured, so as not to feel overwhelmed when studying complex material.

The current findings complement previous studies in example-based learning with additional insight into learning satisfaction. Although this study can prove that MBE is superior to VBE and PBE, it still has limitations. The most basic limitation is the small number of samples and the type of test used. The findings of this study may be able to obtain different results if using a larger number of samples and the type of test used such as other tests such as multiple choice. Further research is expected to involve more participants and use different types of tests. In addition, current study was focused on general performance and satisfaction by quantitative analysis, this study recommends narrative studies to disclose detailed performance and satisfaction per individual case for future research.

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