RESEARCH ARTICLE

Common Pitfalls in Quantitative Research – A Game of Family fortunes

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Abstract

Common pitfalls in quantitative research were examined with two audiences using a Game-Based Learning (GBL) approach to support the engagement and interaction of participants. The researcher asked the UK mathematics and statistic community to determine the game's answers. This approach ignited an enthusiasm to discover the benefits, which was later delivered at the CETL/MSOR annual conference. The paper explores the design and delivery of the Game-based learning session and evaluates how this action research can benefit teaching quantitative concepts in the future.

Keywords: Game Based Learning, Quantitative research mistakes.

1. Introduction

This paper evaluates a session delivered to two audiences; the session delivered was called "the common pitfalls in quantitative research". One audience was a group of novice and experienced researchers, and the other was an audience of statisticians and mathematicians at the annual CETL/MSOR in 2022. The session was designed to incorporate the common mistakes students make during quantitative research to highlight that errors are often made when planning research. Following a request to put together a workshop about quantitative research for novice to experienced researchers, it was decided that any information delivered should be placed in an active and enjoyable format.

Metcalfe's (2017) research on learning from errors highlights the importance of making errors to support the learning process and although the session did not allow errors to be made, it helped facilitate a safe environment to discuss common pitfalls or mistakes in quantitative research. Whilst there has been research about the common mistakes found in journal articles, there is limited research explicitly examining students' common mistakes of quantitative research planning and analysis. Kovach (2018) wrote about statistical mistakes that she had seen when editing journal articles. She felt that authors needed to provide a more robust analysis to provide readers with enough accurate statistical information to evaluate the analytical research. The research, although insightful and valuable in terms of the common mistakes, was only one researcher's insight into what she felt were the common mistakes to avoid in quantitative research. Similarly, Kim and Lee (2018) also explored the common pitfalls in sports journal articles stating their concerns and how they could be managed. The article is relevant in that they found common mistakes. However, they mainly focussed on the analysis end of the quantitative research and less on the planning problems students face with quantitative research. As well as this research, many books outline how to carry out quantitative research and include ways of minimising common mistakes. However, there is little mention of what common mistakes are made.

The researchers had their own opinions of the common mistakes seen in student work, but it was limited to their experience. Therefore, a collaborative understanding using experts within different institutions across the UK was completed via a questionnaire. This approach allowed the researcher to explore the main pitfalls practitioners find within student work which would then be used as the basis of the family fortunes game. Generating the questionnaire provoked intrigue within the mathematics and statistics community and the researcher was approached to present the session at the Annual CETL/MSOR conference. When referring to the delivery of the session both were completed in a similar format albeit to different audiences.

The family fortunes game was chosen because the topic had more than one right answer and enabled participants to guess the answers. This game-based learning (GBL) approach was adopted to improve audience interaction as it is an active teaching approach placing the students at the centre of the learning process. Wiggins (2016) defines GBL as learning and teaching using actual games to facilitate content. Literature has demonstrated that GBL can improve student perception of learning (Hosseini *et al.*, 2019), student motivation and performance (Subhash and Cudney, 2018). Holistic elements of GBL delivery have also demonstrated an impact on learning. Ariffin *et al.* (2014) proposed that if ethnic and cultural elements are portrayed in the GBL environment, it positively correlates with motivation to learn. GBL has been researched extensively within higher education and in a variety of disciplines, including engineering (Markopoulos *et al.*, 2015), nursing (Adamson *et al.*, 2018) and mathematics (Naik, 2017). The family fortunes game was perceived to be the best format to engage participation and offer interaction to formatively assess the audience's knowledge.

With the away day audience in mind, the chosen game helped to incorporate social cohesion and support those with little quantitative experience. Discussing the common pitfalls of quantitative research allowed the teams to share ideas and learn from each other. Whitton (2012) defines this concept as collaborative gaming, where a group works together to find the answer to a question or concept. This social constructivist approach enhanced group discussion and was a supportive environment for novice researchers to be involved in the session.

2. Method

The methods section examines the methodology used to research the answers to the common pitfalls in quantitative research and then outlines the session's delivery, including the teaching approach.

2.1. Research to explore the common quantitative pitfalls

The research to collect the common pitfalls in quantitative research is a single exploratory case-study methodology. The single design is appropriate as the researcher investigated a single issue and did not attempt to describe or explain causality (Yin, 2017). It was felt that these answers from the research would offer a credible insight into common pitfalls in quantitative research using an action research approach.

2.2. Collecting and analysing the results

The approach chosen to collect practitioners' thoughts was a questionnaire with three open-ended questions. The researcher chose this methodology to get the opinion of as many quantitative practitioners as possible without pre-empting the answers. The use of open-ended questions had both advantages and disadvantages. The main advantage of this research was that, as previously mentioned, participants were not given a pre-determined set of answers, allowing them to think and respond to the questions with their own thoughts and words (Allen, 2017). In addition, the approach provided 'a rich description of respondent reality at a relatively low cost to the researcher' (Jackson et al., 2002). The disadvantage of this approach was mainly the time taken to analyse the findings, as the answers needed interpreting and grouping in key pitfalls themes. This approach also could lead to researcher bias in understanding the responses and their grouping (Guba and Lincoln, 1994).

Other methodological approaches considered and rejected were interviewing practitioners about their opinions or providing a survey with pre-determined answers for them to mark. Interviews were not an option for this research as the time scale was limited, and the researcher needed a complete list of practitioners to determine a representative sample. Using pre-determined answers was excluded as although the lead researcher had her own opinions of the answers, it was unknown if the list was exhaustive.

The questionnaire was emailed to two user groups if statistics practitioners -Sigma and Allstat. Sigma is a network for excellence in mathematics and statistics support' (SIGMA, n.d.), and Allstat is a UK-based JISC mailing group for the statistical community created for the Higher Education Authority (HEA) (HEA, n.d.). These two lists cover mainly the UK but are worldwide in their membership. Using these two groups meant sending out a request to complete a questionnaire was straightforward and time efficient. However, using email lists means the lists are incomplete, and those not on the lists may have different answers to those that responded. Not having access to all practitioners is a limitation of this research, although the researcher found that the participants' answers were expected from her knowledge.

The three questions focussed on different stages/areas of quantitative research where common mistakes were made; planning and designing a quantitative study; creating a questionnaire; and mistakes when analysing and reporting results. Respondents were asked to provide their top three common mistakes, as it was known that there could be numerous answers - these focused respondents to think about the most common mistakes rather than any. Three answers for each question enabled a larger population of responses. The questions were: -

1. What are your top 3 common pitfalls that students have within their quantitative research in terms of their research design and method of research?
2. What are your top 3 common pitfalls that students have when creating a questionnaire?
3. What are your top 3 common pitfalls that students have when analysing and reporting their analysis?

An inductive thematic analysis was used to group responses into common pitfalls. An inductive approach was appropriate as the research looked 'for patterns and relationships in the data' (Woo et al., 2017). The 'thematic analysis involves the searching across a data set, be that a number of interviews or focus groups, or a range of texts to find repeated patterns of meaning' (Braun and Clarke, 2006). Firstly, the researcher read and familiarised herself with the responses and created initial common pitfalls groups; the researcher then reviewed the results again, revising the pitfall groups and defining them.

2.3. The teaching sessions

The workshop was shared with two different audiences. The first was staff within the Library and Learning Services Department of the University of Northampton and the second was at the CETL/MSOR 2022 conference. The first audience consisted of 18 staff members with a range of research experience and the second audience mainly of 40 mathematics and statistics practitioners.

2.4. Teaching Approach

The data gained in the questionnaire was used as a basis of the family fortunes game in both sessions. The researcher shared the game on the classroom digital display (Figure 1.) whilst the room was split into two teams.

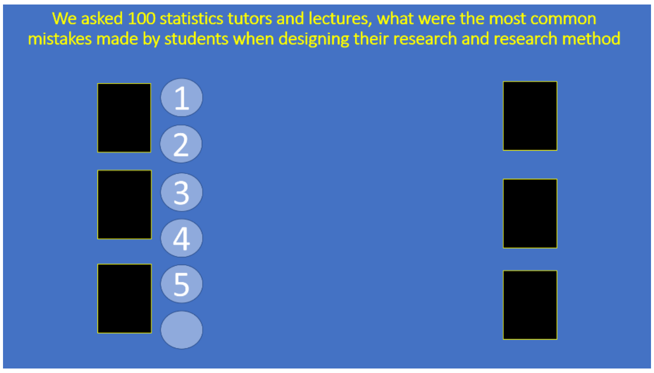

Figure 1. Family fortunes beginning screen

For the first part of the game, one team member came to the front of the class to play 'fastest finger first'. The first question was read out to the two nominated team members and the player to hit the buzzer first answered. The game was adapted from the television version to allow the players to collaborate with their teams. If the answer given was the top answer on the board, the team could choose to continue to play or pass. The other team could guess an answer if the team did not get the top answer. If this answer was higher than the first team, they were offered the option to play or pass. Once a team decided to play, they took control of the board and had to guess all relevant answers to the question.

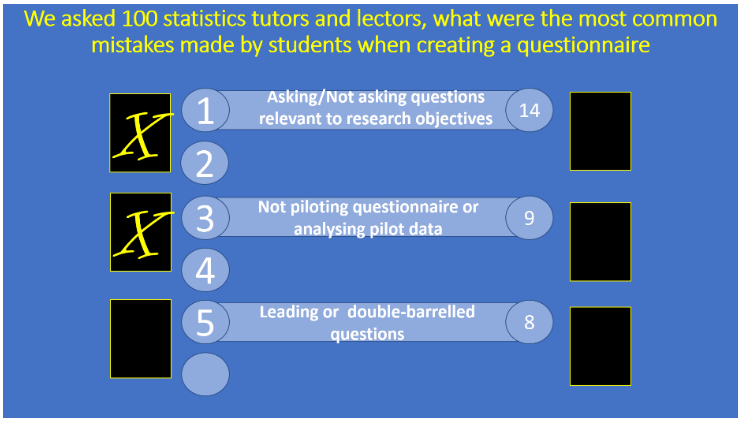

Figure 2: the family fortunes game part way through. The team has got three answers so far and two incorrect answers.

Once the team got an answer correct, they continued to find the other answers. A loud sound was activated and a yellow cross signified any incorrect answer given (figure 2). The game ended once the team correctly guessed all answers. If the team answered the questions incorrectly three times, the control of the board moved to the opposing team. This team then only needed to give a correct answer to win the game.

2.5. Facilitator reflections and participant feedback

As with any action research, it is essential to understand how the facilitator and participants felt the session went, whether they learnt anything from the session and whether any improvements to the teaching methods used. Following both teaching sessions, an email was sent to the participants and the email lists asking them what went well and what could be improved. A total of six participants from both sessions provided feedback.

3. Results & Discussion

This section will outline the results of the questionnaire, the facilitator's reflections and the participant's session feedback.

3.1. The questionnaire

Fifty-three quantitative practitioners responded to the questionnaire relating to the common mistakes, providing between 121 and 132 responses per question. Each of the question's responses were aggregated into categories. Table 1 is an example of the answers contributing to the "Ambiguous or badly worded questions" category highlighting which responses were collectively placed in each theme.

Table 1. All responses categorised in Question 2 response "ambiguous or badly worded questions"

Ambiguous or badly worded questions	**13**
Ambiguous questions	7
Lack of precision in wording	2
Questions are not distinctive	1
Questions don't ask what they think	3
Creating complicated or badly worded questions	2

Due to the format of the game, only the highest five categories were used, and the rest of the responses were grouped into 'other' category. The three questions results can be seen in in Tables 2, 3 and 4.

Table 2. Top 5 common mistakes in terms of planning and designing quantitative research reported

Misconception	Number of responses	Percentages
No/unclear hypothesis or objectives	17	14
Sample size not calculated/ wrong	16	13
Inappropriate design/no design	13	11
Sample not representative to population	10	8
Not planning analysis ahead of collecting data	8	7
Other	58	48
Total	122	100

Table 3. Top 5 common mistakes in terms of creating a questionnaire reported

Misconception	Number of responses	Percentages
Asking questions/ not asking questions relevant to research objectives	19	14
Ambiguous or badly worded questions	13	10
Not piloting questionnaire or analysing pilot data	12	9
Poor question scales including excluding N/A or Neutral	11	8
Leading or double-barrelled questions	10	8
Other	67	51
Total	132	100

Table 4. Top 5 common mistakes in terms of analysing and reporting results reported

Misconception	Number of responses	Percentages
Using or not using p-value, significance, intervals, effect size	17	14
Wrong test	16	13
Analysis not linking to research	11	9
Not writing statistical findings correctly	10	8
Not doing/doing too many doing wrong - graphs and tables	9	7
Other	61	49
Total	124	100

The top five answers gave just over half of the results within each question. The "other "category, outlined in each question, saw 48% (n=58), 51% (n=132) and 49% (n=61) of answers to questions 1 to 3 respectively. Although there were some common themes, each practitioner outlined their own opinion, which meant more categories. These categories were still valid mistakes, but for the game format, the answers were designed into the top 5 mistakes using the number of responders to dictate this calculation. For example, question 2, "having an exhaustive list of options in a question" was reported by nine respondents and "the questionnaire needed to be shorter" by eight respondents. These were common mistakes, but they didn't quite make the top five.

3.2. Facilitators Reflection

Ahead of the two sessions, I felt apprehension as I did not know if the audience(s) would be able to answer the questions. I expected the session to be engaging and was not disappointed. Both audiences engaged with the activity, and the sessions, from my view, were fun. The away day audience struggled to find the answers, and towards the end of the activity, I offered hints to support their answers. Only a few more experienced researchers in each team found the missing answers. This insight may mean that this activity may work better as a formative assessment approach at the end of a teaching session to check students' knowledge rather than as a teaching approach.

The more knowledgeable CETL/MSOR audience were also engaged with the activity. The audience was so engaged that I felt, as the presenter, that my engagement levels within the activity also rose. The room appeared to be 'buzzing' with excitement and enthusiasm. Although the audience were experts, they found finding the top five answers challenging as they all had their own opinions. Each team got 4 out of 5 answers for each question before the game was passed to the other team, adding to the excitement of the game.

One of the main issues with both sessions was the time allocated to complete the game. The away day session ran out of time with only two questions being answered, and the CETL/MSOR conference overran, with the organiser allowing the game to be completed. From my reflections, each question takes 10 minutes to complete, even with an experienced audience. Therefore, the time allocated for the session needs to be 30-40 minutes. If time is limited, it would be more productive to only offer one question at a time to ensure the interest of all participants is held because some of the audience motivation dropped in the away day session.

The research was insightful for practitioners as it can be used in teaching to help positively rectify common mistakes. For example, the top results in the first two questions included that students did not create hypotheses or ask questions related to their hypotheses/aims of the study. This research clearly showed these areas as a focus when teaching quantitative analysis. The final question reported students' lack of knowledge when calculating their statistical findings, with students not knowing which statistical tests to use for their interpretation and reporting. A flow chart or guide may be helpful in supporting students who fail to understand this aspect of their research.

3.3. Participant Feedback

All six participants providing feedback gave positive experiences of the sessions and how the sessions could be improved. From the six respondents, there were common responses within the feedback that were both positive and negative. This section will explore their feedback.

The participants found the game fun and enjoyed the game's competitive element. They also thought about how it could be used to teach the topic. All six respondents found the session fun and engaging and felt it created a positive environment to collaborate with others. This finding is in line with other research where students found a game-based learning approach fun and motivating (Chan *et al.*, 2017; Al-Azawi *et al.*, 2016). A couple of the quotes below show both the fun element as well as how it engaged the participants:

> *'Activities that involve the audience are always good from an audience member's point of view. It encourages you to think about what is being presented'*
>
> *'It was fun (for us); it got us thinking - including "What would other people think/say?"; it was informative ("Oh, I didn't think of that !")'*

The game's competitive element also came out as positive within the feedback. Two quotes below show the emotional competitive value of the game:

> *'Wish that we won!'*
>
> *'The family fortunes format allowed us to work as a team to provide answers but also added an element of gamification as we were in competition.'*

This positive competitive view agreed with Burguillos (2010) research which suggested 'that the combination of game theory with the use of friendly competitions provides a strong motivation for students; helping to increase their performance'.

The last comment highlighted the engagement element, the respondents also thought about the teaching practice and how it would work in other classes. The feedback expanded on this, exploring whether it would be an effective way to introduce a topic of mistakes and how it could be used to teach novice researchers. One participant suggested that this would be good as a starting point that could lead to a discussion of what errors students might make.

The feedback also outlined how the teaching approach could be improved. The key elements to focus on enhancing were the timing of the teaching, the approach to grouping answering being different to how the participants might group them and the problem that more than the top five answers would be helpful. Most feedback mentioned that the session overran or that the time constraint meant there was no time to expand on the answers. This feedback can be seen in a couple of the feedback quotes below:

> *'Obviously the time constraints of the talk meant that you weren't able to expand too much on how you might use the game.'*
>
> *'There wasn't enough time for the activity so it seemed rather rushed and so wasn't as effective as it could have been.'*
>
> *'I believe we ran a bit short of time during the event, but I really liked the format.'*

Two participants felt the answers for the questions used different wording to that given in the answers meaning that the presenter had to match the audience's responses to those in each question, which caused confusion.

> *'As an audience member, I felt there was a mismatch between the language used in the activity (answers given by M&S tutors) and the language used by the audience. This made it confusing to take part as I wasn't sure what was meant by some of the responses on the screen and there seemed some confusion from the presenters over which response on the screen should be matched to the audience suggestions.'*
>
> *'Perhaps ensure that the questions have a relatively well-defined (closed?) set of possible answers, to avoid excessively vague wordings of responses?'*

The feedback for improvement was that the game approach of only the top five answers was too narrow. One participant's feedback suggested that it would have been good to see more of the answers as it was a topic that was hard to narrow down into categories.

4. Conclusion

Who knew that a session request to speak about quantitative research on an away day could generate such an impact? The GBL design was adopted for this request, and the data required for the game was analysed. The enthusiasm of the mathematics and statistics community to share their knowledge on the common mistakes was remarkable. This enabled insight that benefited the community by offering ideas that could help the future teaching of these concepts.

Using the GBL as an approach was a positive experience for both the facilitator and the participants. When thinking about translating this approach to classroom teaching it is crucial to ensure enough time is allocated to complete the game. Given time constraints, it maybe more beneficial to separate the game into parts relating to the teaching and to keep students attention and manage time. The GBL was great, but when working with concepts which participants have less experience and knowledge, it would be better to complete the GBL as a formative assessment after the content has been taught. This way, all participants will have the ability to engage in the game.

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