Game Based Learning in Mathematics: To what extent do teachers and students in one special educational needs school believe that game based learning in mathematics lessons impacts the learning of the students?

Abstract

This qualitative case study aimed to identify the impact of game-based learning in mathematics on students' learning. Game based learning (GBL) can take several forms under two distinct categories: digital and non-digital. Literature identified that a primary use of game-based learning was to improve the motivation and engagement of students to positively impact on learning. Semi-structured interviews collected the experiences and thoughts of mathematics teachers, in which it was identified that, where motivation and engagement were positively impacted, students' ability to focus and learn were improved. Using prompts, a focus group provided the students with the opportunity to discuss their opinions and experiences, highlighting the students' need for personalisation and the way in which game-based learning impacts their learning. The conclusion discusses the extent to which areas of GBL impact students' learning within mathematics and suggests recommendations for improvements and further research.

(Sandvig, 2016)

Introduction

This dissertation seeks to understand the impact of game-based learning (GBL) on students' learning in one special educational needs and disability (SEND) school. The setting caters for boys aged 5-19 years of age, providing a differentiated curriculum to meet the needs of the students and support learning. My role within the setting was to work with the teacher to ensure that the environment and content met the students' needs and that the students were progressing academically and personally. Thus, my role required me to be observant of student behaviour and interests so that lessons could be adapted accordingly. Within mathematics, students often displayed improved motivation and engagement to learn when GBL activities or elements were applied to the mathematics activities. This was also evident in other lessons, however, mathematics seemed to be one of the least enjoyed subjects. Therefore, the improvements in participation and motivation were clearly evident in comparison to the students' usual behaviour and engagement during mathematics lessons. Consequently, exploring the impact of GBL in mathematics on students' learning became the primary aim of this dissertation.

Seeking to understand how GBL may impact the students' motivation and, thus, their learning, a literature review is provided. Upon initial research, it became apparent that digital GBL research was abundant, whereas non-digital forms of GBL were less explored. However, to support the students' needs and learning, the setting employs a range of GBL formats in mathematics, including digital, such as online games, and non-digital, which includes card or board, physical and group games. Therefore, it was not possible to highlight specific applications of GBL within the literature, due to the diverse and complex application of GBL in the setting and the limited word count.

Consequently, the impacts of specific GBL elements were explored to identify the impact this may have on the students' motivation and engagement, and, hence, learning. The literature review explores the definition of GBL, and the impact of instructional support, personalised learning and motivational strategies.

To ensure subjective and representative data was collected, a qualitative case study was used to gather data from semi-structured interviews and a focus group. The data collected from teachers and students are provided in the findings and discussion. Both sets of data are discussed independently to analyse the specific impacts of GBL. A conclusion is then made to establish the impact of GBL in mathematics on students' learning. Recommendations will be discussed regarding the data and literature.

(Google Images, 2018a)

Literature Review

Game Based Learning

GBL is the use of games to reinforce learning in which game elements, such as reward systems, may be used to motivate and engage the users to promote learning (Jackson, 2016), although this definition was formed from Jackson's (2016) research that focussed on only digital GBL. However, Bragg (2012), who researched digital GBL in mathematics, concluded that GBL, with or without game elements, can promote learning within lessons, such as mathematics, by meeting students' learning needs. Differently, Naik (2015) considered both digital and non-digital GBL within mathematics and found that GBL can reduce negative behaviours and attitudes, and so raise motivation and engagement towards learning content by making activities entertaining. Thus, Bragg's (2012) and Naik's (2015) understanding of GBL may be more reliable and applicable to the different forms of GBL in mathematics than Jackson's (2016) definition. Consequently, GBL may be defined as a flexible approach to pedagogy in which games and game features can be applied to activities to meet the needs of the learners and encourage motivation, engagement and learning.

Meeting the needs of the students within mathematics requires a combination of independent investigation and social interaction to improve understanding and skills (Hudson, Henderson & Hudson, 2015).

(Google Images, 2018b)

Specifically, Mooney, Briggs, Hansen, McCullouch and Fletcher (2018) state that interactions between peers and teachers allow students to develop skills in applying and using mathematics, to which students are then able to learn beyond their capabilities if help is provided by others. Consequently, when applied to Mathematics, GBL can support the learning of concepts and skills (Ya-Ting, 2012) as GBL challenges students' current knowledge and understanding, promoting investigative and communicative skills (Dragona, 2014). Independent learning within GBL may reflect Piaget's (1936, cited in Olsen & Hergenhahn, 2016) cognitive learning theory where learning occurs when children actively construct knowledge through interacting with their environment. Whereas, collaborative learning in GBL may be similar to Vygotsky's (1978, cited in MacBlain, 2014) social learning theory in which children develop their understanding through talking and listening to others. Therefore, independently and actively constructing knowledge through games promotes students to communicate and collaborate with their peers and teachers, refining and developing the students' understanding, thus, promoting learning (Hennessey, Higley & Chesnut, 2012). Subsequently, GBL within mathematics may promote effective and positive independent and collaborative learning, which is encouraged through the use of games that positively impact upon motivation and engagement of students.

Instructional Support

Vandercruysse et al. (2016) state that when instructional support, any type of support, direction or teaching that helps students learn, is applied to GBL, students' learning improves. Accordingly, Hung, Huang and Hwang (2014) found that feedback and scaffolding during digital GBL in mathematics promoted intrinsic motivation as students felt more confident and competent. Offenholley (2012) also found that instructional support promotes self-efficacy, an individual's belief

(Google Images, 2018c)

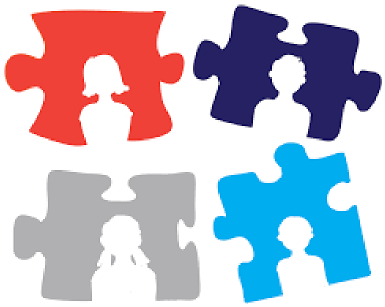
regarding their ability to succeed, which improves intrinsic motivation and, thus, improves confidence to learn. This reflects the principles of Wigfield and Eccles' (2000, cited in Lauermann, Eccles & Pekrun, 2017) expectancy-value theory in which the motivation of individuals is impacted by how the individual expects to perform and the level of intrinsic value the individual has for a subject. Thus, it appears that instructional support methods can positively impact intrinsic motivation, which may encourage learning as students become increasingly confident.

Erhel and Jamet (2013) identified feedback as a factor in promoting a deeper understanding of mathematical concepts, however, this depends on how the feedback prompts learners to actively process content, reflecting Piaget's (1936, cited in Olsen & Hergenhahn, 2016) cognitive learning theory. Comparably, Wouters and Oostendorp (2013) conclude that without instructional support, mathematical learning may be negatively impacted as opportunities, such as the provision of feedback, to stimulate learning may be overlooked. Likewise, Liu and Rojewski (2013) concluded that where students have poor intrinsic motivation, feedback and scaffolding may not be effective in improving learning or motivation due to decreased confidence. Arguably, feedback may positively impact intrinsic motivation and, thus, learning by promoting student confidence (Hung et al., 2014; Offenholley, 2012), yet, the extent to which feedback in GBL can promote deeper learning and understanding, may require further investigation (Erhel & Jamet, 2013; Liu & Rojewski, 2013; Wouters & Oostendorp, 2013). Therefore, further studies on the impact of instructional support on motivation may identify the extent to which instructional support promotes self-efficacy and learning. Nevertheless, it appears that instructional support, particularly feedback, could support students' understanding and intrinsic motivation, allowing them to engage and learn effectively with GBL.

Personalised Learning

GBL may be effective in promoting deeper learning and engagement in students when GBL activities and experiences are personalised to the learner (Evans, Pruett, Chang & Nino, 2013). Personalised learning is the adaptation of education to students' learning needs, interest and pace (Duncan & Cator, 2013), which influences the strategies and approaches applied by the teacher to instruction and activities to promote motivation and, thus, learning (Rickabaugh, 2016). However, Peirce and Wade (2010) found that personalisation is difficult to achieve in GBL as it is time consuming to cater for each individual without having adaptive technology. This suggests that digital GBL can be personalised using adaptive technology, whereas adaptive technology may not be suited to non-digital forms of GBL. Nevertheless, Watts-Taffe et al. (2012) state that personalisation can be recognised in the form of differentiation, the way in which content, processes and evidence of learning are tailored to the needs of students, as this encourages children to feel supported and competent, motivating students to engage and learn. Watts-Taffe et al. (2012) found that the teacher's ability and confidence to use differentiation to provide some personalisation impacted its effectiveness in GBL. However, Zarraonandia, Ruíz, Díaz and Aedo (2012) found that differentiation within GBL can be provided by teachers through the differentiation of difficulty, time, options or rules to maintain interest and meet students' learning needs, which supports learning and provides a form of personalisation. It could be argued that differentiation allows for personalisation to meet groups of needs, such as a group who need extra time in a game, as opposed to providing personalised learning on an individual basis. Thus, differentiation may provide an effective form of personalised learning, minimising the time needed for planning whilst aiding motivation and learning. Subsequently, differentiation and personalisation during GBL could be used synonymously in regard to supporting groups of learning needs to improve motivation and learning.

Trinter, Brighton and Moon (2015) found that GBL within mathematics provides personalisation as the differentiated content within the games reflected the needs of the students and, thus, the students were able to develop their knowledge. Comparably, Konstantinou-Katzi, Tsolaki, Meletiou-Mavrotheris and Koutselini (2013) found that differentiation improves engagement and motivation of students within mathematics as teachers were more able to support various needs, which improved student confidence and learning. This suggests that differentiation may develop students' motivation and confidence to engage with mathematics and positively impact learning. However, differentiation of GBL in mathematics requires a consideration of individual learning styles to be effective (Hwang, Sung, Hung, Huang & Tsai, 2012). Whereas Prain et al. (2013) state that teachers' expertise and confidence can impact the effectiveness of GBL in supporting students' learning through the promotion of motivation and confidence. Additionally, Vasileva-Stojanovska, Vasileva, Malinovski and Trajkovik, (2014) recognise that the effectiveness of GBL activities are impacted by the way teachers implement differentiation as Rytivaara and Vehkakoski (2015) argue that noticeable differentiation can place a focus on a child's need, causing anxiety and issues in focusing, reducing learning potential. Therefore, personalised learning in GBL requires consideration for the teacher's expertise and confidence, and the impact differentiation may have on students' holistic development and learning. Thus, supporting the needs of students in GBL could have a positive impact on the students' motivation, confidence and learning if the factors impacting on GBL personalisation have been considered.



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Motivation

Reward systems, such as students receiving points or badges once an outcome or skill is achieved, in GBL is one game element that may be utilised to increase students' extrinsic motivation to positively impact the learning of mathematics, through increased student engagement and participation (Preiss-Groben & Hyde, 2017). According to Sartawi, Alsawaie, Dodeen, Tibi and Alghazo (2012), extrinsic motivation is the action of performing a behaviour or engaging in an activity to earn a reward or to avoid punishment. However, Wentzel and Brophy (2014) state that a child will only be extrinsically motivated by rewards if the child believes they have a chance of getting the reward. Comparably, Fielding-Wells, O'Brien and Makar (2017) concluded that low levels of confidence in students resulted in lower performance expectation and, hence, the students displayed lowered motivation to engage with mathematics activities, reflecting Wigfield and Eccles' (2000, cited in Lauermann et al., 2017) expectancy-value theory. This indicates that extrinsic motivation changes according to the student's expectations and confidence regarding a GBL activity. Comparably, Deci, Koester and Ryan's (1999, cited in Filsecker & Hickey, 2014) cognitive evaluation theory states that when rewards are used to gain extrinsic interest, the rewards are likely to be perceived as restrictive by students and, thus, impact the students' autonomy of learning mathematics, resulting in lowered intrinsic motivation due to lowered feelings of competency. Therefore, rewards may increase extrinsic motivation to the detriment of intrinsic motivation, resulting in ineffective learning and engagement. Consequently, the impact on both intrinsic and extrinsic motivation may need to be considered when applying reward systems in GBL to minimise negative impacts on confidence and learning.

Abramovich, Schunn and Higashi (2013) found that the use of reward systems can negatively impact intrinsic motivation as the students lost interest in the learning, aiming to only gain the reward. Intrinsic motivation is engaging in behaviour or activities for personal fulfilment, such as doing an activity for enjoyment as opposed to doing the activity for a reward (Mujtaba, Reiss & Hodgson, 2014). However, Dörnyei and Ushioda (2013) state that skill-based and performance rewards can be applied to other reward systems, stating for example that a child could receive five points for displaying a new skill or completing a task. Therefore, it could be suggested that intrinsic value is not supported as reward systems encouraged extrinsic motivation to gain participation. This is supported by Hanus and Fox (2015) who studied various reward systems, such as badges and team points, and identified that reward systems encouraged competition, resulting in the students' confidence being negatively impacted when they did not receive the reward. Consequently, the students began to dislike the activity, resulting in a loss of intrinsic and extrinsic motivation to engage. Evidently, further strategies to support intrinsic motivation during reward systems may need to be identified.

Dichev, Dicheva, Angelova and Angre (2014) identified that the use of feedback may mitigate the negative motivational effects of reward systems, subsequently meeting the students' motivational and learning needs and positively impacting on confidence and learning, as opposed to promoting competition. Particularly, feedback supports students to reflect and improve their actions, which may support confidence and improve intrinsic value (Wasserman & Banks, 2017). Thus, this may reduce the negative impact on motivation identified in Deci et al.'s (1999, cited in Filsecker & Hickey, 2014) cognitive evaluation theory regarding the use of reward systems in GBL. Subsequently, Nadolny and Halabi (2016) suggest that feedback promotes discussion in which the students may independently or collaboratively re-engage with the activity, echoing Piaget's (1936, cited in Olsen & Hergenhahn, 2016) cognitive learning theory and Vygotsky's (1978, cited in MacBlain, 2014) social learning theory. Therefore, feedback may allow for students to recognise their potential, possibly increasing their confidence, intrinsic motivation and learning through interactions with others and the GBL environment. Although the use of rewards may have a negative impact on intrinsic motivation, the use of feedback, may reduce this and so may provide positive intrinsic motivation. Subsequently, students may engage with the reward system and GBL activity, assisting with learning and meeting the personal and learning needs of students to promote positive holistic motivation and learning.

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Findings and Discussion

Introduction

The aim of this research project was to understand the impact of GBL in mathematics on students' learning. Specific themes within each set of data were identified and so each set of data will be discussed separately. Within the teachers' data the themes identified were: teacher factors, reward systems, personalisation and differentiation, and instructional support. Regarding the students' data, the themes identified were: confidence, impact of GBL on learning and motivation, personalisation and differentiation, and reward systems.

Teacher Findings

Teacher Factors

Confidence and training were identified as key factors for the successful implementation of GBL in mathematics to effectively support students' learning. Teacher 2 identifies self-confidence is needed for GBL to be successful in positively impacting students' learning in mathematics. However, Teacher 3 suggests that their confidence to use GBL is impacted by their confidence to teach mathematics. This suggests that a lack of confidence may negatively impact the teacher's use of strategies, as recognised by Watts-Taffe et al. (2012). However, the confidence of each participant may coincide with their length of service, as Teachers 1 and 3 have been teachers for five years, whilst Teacher 2 has been a teacher for over 20 years. This suggests that inexperienced teachers may not effectively implement GBL due to underdeveloped confidence, resulting in the teachers failing to support students' learning effectively. GBL training to provide further confidence, tools and knowledge was recommended by Teachers 1, 2 and 3. This is echoed by Prain et al. (2013) where it is suggested that promoting teachers' training in using GBL could reduce the negative impacts on GBL in mathematics. Thus, teacher confidence to implement GBL may improve, potentially mitigating some issues surrounding length of service and confidence to utilise GBL.

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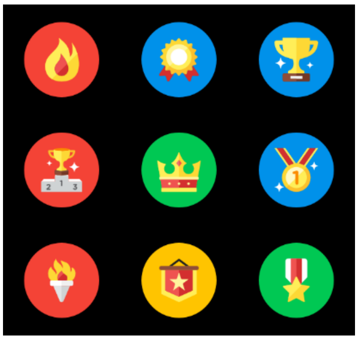
Reward Systems

All four teachers recognised that the use of points, either through incorporating school-wide policy or lesson specific point systems, appear to encourage students to engage in the activity and improve the students' motivation to participate. This suggests that the use of reward systems to motivate and engage students positively impacts students' learning, which, according to Sartawi et al. (2012), can be recognised as extrinsic motivation. Both Teachers 1 and 2 felt that reward systems can increase the interest of students, whilst Teacher 4 found that applying GBL to mathematics can encourage students to continue with an activity independently or in



a group. Conversely, Teachers 2 and 3 identified that the use of reward systems in a competitive activity could cause students to feel undervalued, which may lead to disruptive behaviour or negative emotions, or poor participation. This echoes Wentzel and Brophy's (2014) statement that rewards will only provide motivation to participate if a child believes they are able to get the reward. Furthermore, Deci et al. (1999, cited in Filsecker & Hickey, 2014) state that this could negatively impact on students' enjoyment of an activity due to decreased intrinsic motivation, resulting in limited learning of content. Thus, using reward systems in the setting may require consideration for intrinsic motivation and the impact competition may have on learning to improve the efficacy of rewards in GBL.

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<u>Personalisation and Differentiation</u>

Personalisation and differentiation of GBL activities within mathematics appear to positively impact the learning and motivation of students. Improvement in students' team working skills, motivation and confidence were identified as positive impacts of personalisation and differentiation by Teachers 2 and 3, highlighting that provision of differentiated difficulty enables individuals to work together or independently regardless of their needs. Teacher 1 recognises differentiation as particularly effective with students with SEND needs, as it enables students to work together to solve problems. Thus, it appears that personalisation and differentiation may be more applicable to students with additional needs, indicating that Rickabaugh (2016) and Watts-Taffe et al. (2012) may be accurate in stating that personalisation and differentiation occur in response to adapting activities to meet the needs of students. However, issues of labelling may occur, with Teachers 3 and 4 highlighting that labelling is difficult to avoid when providing differentiation or personalisation which can cause anxiety if students feels that their needs are obvious to others. This concern is recognised by Rytivaara and Vehkakoski (2015) who state that highlighting the needs of a child can negatively impact on learning due to increased anxiety and so this may require consideration when using personalisation and differentiation in GBL.

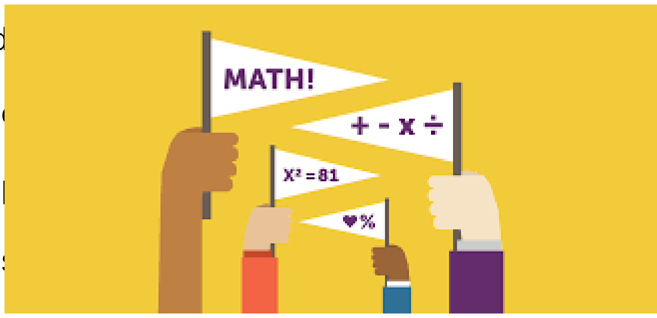
Instructional Support

Instructional support is a key skill in which all four participants utilise to promote the engagement and learning of students. Specifically, feedback and scaffolding were identified as important in supporting students' understanding of mathematical concepts during GBL activities. Teacher 4 believes that this allows students to access content and resources whilst Teacher 2 found that instructional support can improve students' engagement and interest in mathematics when using GBL due to increased confidence. This reflects Hung et al. (2014) findings that suggest feedback and scaffolding promotes intrinsic motivation due to increased confidence in students. Similarly, Teachers 1 and 3 identified that providing support and feedback to students encourages students to participate, increasing their focus and learning. This is reflected by Offenholley (2012) who argues that instructional support decreases students' issues regarding self-efficacy and improves their interest and enjoyment of an activity, thus, allowing them to enjoy their learning. This suggests that instructional support may be an effective tool to increase students' intrinsic motivation through developing their confidence.

Student Findings

Confidence

Three of the students highlighted that their participation in GBL activities is dependent upon their confidence in themselves to participate in front of others. Particularly, it appears that students are less intimidated by individual or partner work, as opposed to group and class activities. Students 1 and 3 identified failing in front of peers as having a negative impact on their participation in GBL and confidence, with Student 4 stating that they preferred individual GBL activities as opposed to participation in group GBL due to their confidence regarding their competence. The impact of confidence on participation in GBL may be explained by Wigfield & Eccles' (2000, cited in Lauermann et al., 2017) expectancy-value theory, indicating that confid [illegible] motivation. Although this is evid [illegible] rgued that their confidence to partici [illegible] in front of their peers, as their prior [illegible] ively impacted their confidence in mathematics.



(Heller, 2018)

Impact on Learning and Motivation

GBL appears to have a positive impact on the students' ability to work collaboratively, their learning and motivation. Three of the participants described how

GBL helps them to discuss their ideas with the teacher or peers. This indicates that GBL encourages the students to utilise their investigative and communication skills when seeking support, which, according to Hennessey et al. (2012) enables students to challenge their current skills and develop them. Moreover, Student 1 stated that talking with a teacher or friend supports them to complete activities they cannot do individually, with Students 2 and 4 agreeing with this statement and stating that additional support maintains their interest and enjoyment. This supports Mooney et al.'s (2018) suggestion that collaboration and support from peers and teachers develop students' skills and learning. Although the students' needs may limit their communicative and collaborative skills, it appears that GBL improves the students' ability to discuss and seek support from their peers or teacher, positively impacting their learning.

Personalisation and Differentiation

Personalisation and differentiation appear to be a focal point in how effectively students engage with and learn from GBL in mathematics. Incorporating the interests of the students promotes participation. Three of the students stated that they prefer GBL activities to be related to something they are interested in or have options to choose from when accessing the activity, such as different levels of difficulty. Although the students may prefer the presence of personalisation and differentiation in GBL, this may be due to their learning needs that require additional consideration when planning activities to ensure each student can participate as fully as possible.

Impact of Rewards

The impacts of reward systems were identified by Students 3 and 4 as improvements in motivation and engagement during GBL learning activities, regardless of whether the activity was independent, or group related. Additionally, Student 1 explained that they will join in if there is a reward and showed a preference for GBL activities that offered rewards, as opposed to those that did not. It appears that the reward systems positively impact students' extrinsic motivation, as Sartawi et al.'s (2012) definition of extrinsic motivation may explain participants' increased motivation when reward systems are used. Conversely, it does not appear that intrinsic value is positively impacted, reflecting Abramovich et al.'s (2013) findings in which intrinsic motivation is negatively impacted as students become motivated to gain the reward as opposed to learning the content behind the GBL activity. However, the students lacked intrinsic motivation to engage with mathematics due to their previous academic backgrounds or experiences. Thus, the students may require reward systems to engage them in GBL activities, although this could further negatively impact intrinsic motivation. Subsequently, additional mechanisms to support intrinsic motivation during reward systems may need to be considered which may allow the children to gain interest to learn the mathematical content.

Conversely, Students 3 and 4 identified decreased confidence, motivation and interest as negative impacts of reward systems in GBL. Both Students 3 and 4 recognised feeling frustrated or angry when this occurred, which resulted in them either losing confidence to try or not being interested in the activity. Consequently, Preiss-Groben and Hyde's (2017) suggestion that reward systems can positively impact extrinsic and intrinsic motivation may not be applicable to setting as it seems that intrinsic motivation is not positively impacted. However, Students 3 and 4 recognised that their SEND needs caused them to become easily frustrated or competitive. Therefore, further exploration of how SEND needs can impact the effectiveness of reward systems during GBL activities may be needed to identify additional strategies to improve the effectiveness of reward systems.

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Conclusion

The way in which strategies and elements are utilised in GBL during mathematics has various impacts on students' learning within the setting. It appears that learning is directly influenced by the way in which motivation and engagement are encouraged or supported. Teachers seem to effectively apply GBL in mathematics, regardless of their experience or confidence, as positive impacts of GBL are identified by both the teachers and students, which shares similarities with the literature. It appears that motivation is a key factor in which engagement and interest are influenced, impacting upon the students' ability to learn effectively in mathematics. This reflects the literature on why GBL may be used (Bragg 2012; Jackson, 2016; Naik 2 [...] learning of mathematics (Dragona, 2014; Henn [...] oreover, it is evident that students value person [...] ay explain the students increased motivation a [...] rmation and investigation of the research question. Likewise, the teachers' use of instructional support may reflect their recognition of the students' needs and lack of intrinsic motivation for mathematics. However, extrinsic motivation is evidently impacted by GBL, although

this may be explained by the students' needs and lack of intrinsic motivation for mathematics. Yet, it is not possible to understand the impact of specific applications of GBL due to the nature of the students and the setting. Thus, the research may provide a limited understanding of the impact on students' learning of GBL in mathematics that is clearly affected by the students' needs. Nevertheless, it appears that, through support and differentiation, GBL in mathematics has an overall positive impact on the students' motivation, which enables students to engage with and learn the mathematical content.

Recommendations

- Further research on the specific applications, such as digital and non-digital, of GBL may be required to understand the extent to which GBL in mathematics impacts learning.
- Identifying strategies or tools to develop intrinsic motivation in GBL within the setting.
- Developing teachers' training and expertise of GBL to further enhance GBL and promote intrinsic motivation
- Consideration to be given for the adaptation of rewards in the setting to minimise negative impact on confidence, motivation and learning.
- Further research to understand the impact SEND may have on the implementation and impact of GBL in mathematics

(Google Images, 2018i)

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